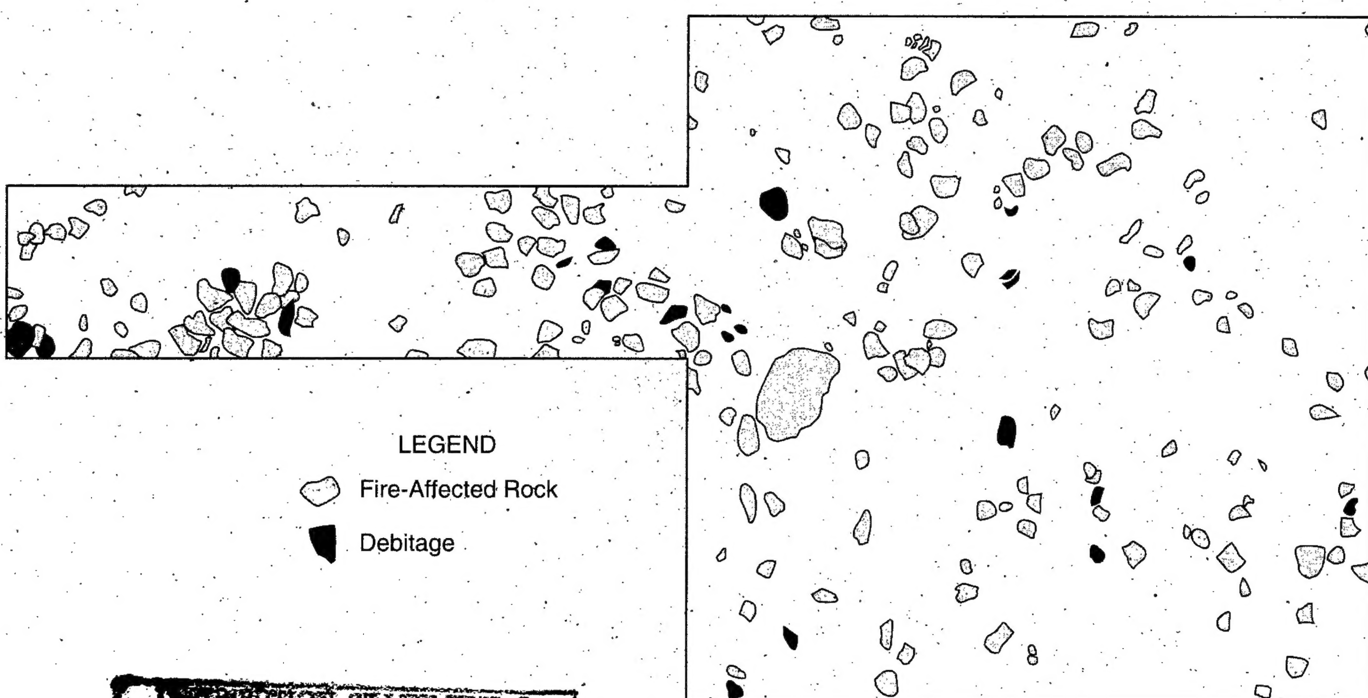
3,000 Years of Prehistory at the Red Beach Site CA-SDI-811 Marine Corps Base • Camp Pendleton California



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This report presents the results of a data recovery project at the Red Beach site (CA-SDI-811), Marine Corps Base, Camp Pendleton, California. The project was designed to avoid adverse effects from the construction of a sewage pipeline injection well field located within the boundaries of CA-SDI-811 near the mouth of Las Flores Creek. The site contains an extensive Archaic/Late Prehistoric deposit, ranging in age from 2400 B.C. to A.D. 1000. CA-SDI-811 appears to have been used as a short-term residential base that was frequently re-occupied during various seasons of the year. The range of animal species exploited, especially the presence of deer and rabbit, demonstrates that the site was used for more than just collecting nearby fish and shellfish.

The Red Beach site, which represents over 3,000 years of prehistory, provides the only recorded information about the end of the Archaic and the transition into the Late Prehistoric period for the Las Flores Creek coastal area. The site fills in a missing time gap and allows for an examination of the changes in the local settlement and subsistence system through time.

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Doug Kennett, Steve Martin, and Dr. Virginia Popper

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Back cover art based on map by **Bean and Shipek 1978:551.**

ABSTRACT

This report presents the results of a data recovery project at the Red Beach site (CA-SDI-811), Marine Corps Base (MCB), Camp Pendleton, California. The data recovery project was designed and implemented to avoid adverse effects from the construction of a sewage pipeline injection well field located within the boundaries of CA-SDI-811 near the mouth of Las Flores Creek. Archaeological fieldwork was conducted between April 28 and May 23, 1997.

The Red Beach site contains an extensive Archaic/Late Prehistoric deposit, ranging in age from 2400 B.C. to A.D. 1000. The archaeological material is composed primarily of flaked stone, animal bone, shellfish, and fire-affected rock. The site appears to have been used as a short-term residential base that was frequently re-occupied over a long period of time during various seasons of the year. The range of animal species exploited, especially the presence of deer and rabbit, demonstrate that the site was used for more than just collecting nearby fish and shellfish.

The Red Beach site, which represents over 3,000 years of prehistory, provides the only recorded information about the end of the Archaic and the transition into the Late Prehistoric period for the Las Flores Creek coastal area. Site investigations demonstrate the existence of intact deposits within the alluvial floodplain, including the only known deposit in the local area dating to the middle of the Archaic Period. The site, therefore, fills in a missing time gap and allows for an examination of the changes in the local settlement and subsistence system through time.

In addition, this investigation introduced a new method for determining the seasonality of Camp Pendleton archaeological sites: isotope analysis of the marine shellfish, *Donax gouldii*. Determining the season of occupation at a site is one of the most difficult tasks to perform, especially for a coastal site because most types of coastal flora and fauna are available year-round and offer no indication of season of exploitation. Shellfish isotope analysis offers a potential solution to this problem. It also has great potential for establishing inter-site variability in seasons of occupation and duration of occupation because *Donax* is present in most of the sites within the Las Flores Creek area.

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Karen Rasmussen was the primary author of the report, and Craig Woodman directed the preparation of the document. Many specialists were involved with both the field and laboratory research as well as the preparation of the report, including faunal analyst Dr. Jean Hudson, California State University, Bakersfield; shell isotope analyst Doug Kennett, University of California, Santa Barbara; geomorphologist Mitchel Bornyasz, Earth Consultants International, Inc.; paleobotanical analysts Steve Martin and Dr. Virginia Popper, UCLA Paleoethnobotany Laboratory; and radiocarbon analysis by Beta Analytic, Inc.

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We would also like to thank numerous military and civilian personnel from Camp Pendleton and Southwest Division for their generous support of SAIC and the positive response they have given our recommendations. Camp Pendleton personnel were instrumental in recommending that SAIC conduct the work, provided project funding, and with key personnel from Southwest Division participated in essential planning meetings resulting in positive and timely decisions regarding the design and implementation of actions to incorporate cultural resource concerns in the development of project alternatives and the selection of a final project route. Key individuals during this process included Dan Muslin, Danielle Huey, and Sheila Donovan from Environmental Planning, Southwest Division. Key individuals from Camp Pendleton included Lupe Armas, Slader Buck, Stan Berryman, Colonel Wayne A. Spencer, Major Caspars, Ed L. Rogers, Commander Mark P. Migliore, and Lieutenant J. M. Farthing.

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1 INTRODUCTION

Karen A. Rasmussen

1.1 PROJECT DESCRIPTION

This report presents the results of a data recovery project at archaeological site CA-SDI-811 located on Marine Corps Base, Camp Pendleton (Figure 1-1) in order to comply with the National Historic Preservation Act (NHPA) of 1966, as amended, and the National Environmental Policy Act (NEPA) of 1969, as amended. The data recovery project was designed and implemented in consultation with the California State Historic Preservation Office to avoid adverse effects from the construction of a sewage pipeline from Wastewater Treatment Plant 9 (WTP) to an injection well field located on the beach southwest of Interstate Highway-5 (I-5) on Marine Corps Base, Camp Pendleton, California. The sewer pipeline will connect with an existing line at WTP 9 and continue southwest on the north shoulder of Las Pulgas Road to the intersection of Las Pulgas Road and Stuart Mesa Road. The pipeline will cross under I-5 and continue to the southeast through the Red Beach training area within the Las Flores Creek floodplain (Figure 1-2). The pipeline will be buried in a trench approximately 2 feet wide and a maximum of 7 feet deep. The pipeline's area of potential effect (APE) is approximately 30 feet wide including room for construction access. The injection well sites will each measure approximately 9 feet by 9 feet. The injection well field is located in the Red Beach training area within the boundaries of SDI-811 (Figure 1-3). Archaeological fieldwork for the data recovery project was conducted between April 28 and May 23, 1997.

1.2 SITE DESCRIPTION

SDI-811 (Figure 1-4) is an extensive Late Prehistoric settlement situated at the mouth of Las Flores Creek, within 0.1 mile of the Pacific Ocean. The site is located within the APE of the proposed action. The site deposit is characterized as moderately intact with moderate densities of cultural materials including flaked stone artifacts, debitage, groundstone, shell and bone beads, ceramics, shellfish, and vertebrate remains representing a wide diversity of marine fish, sea mammals, birds, and various types of terrestrial mammals.

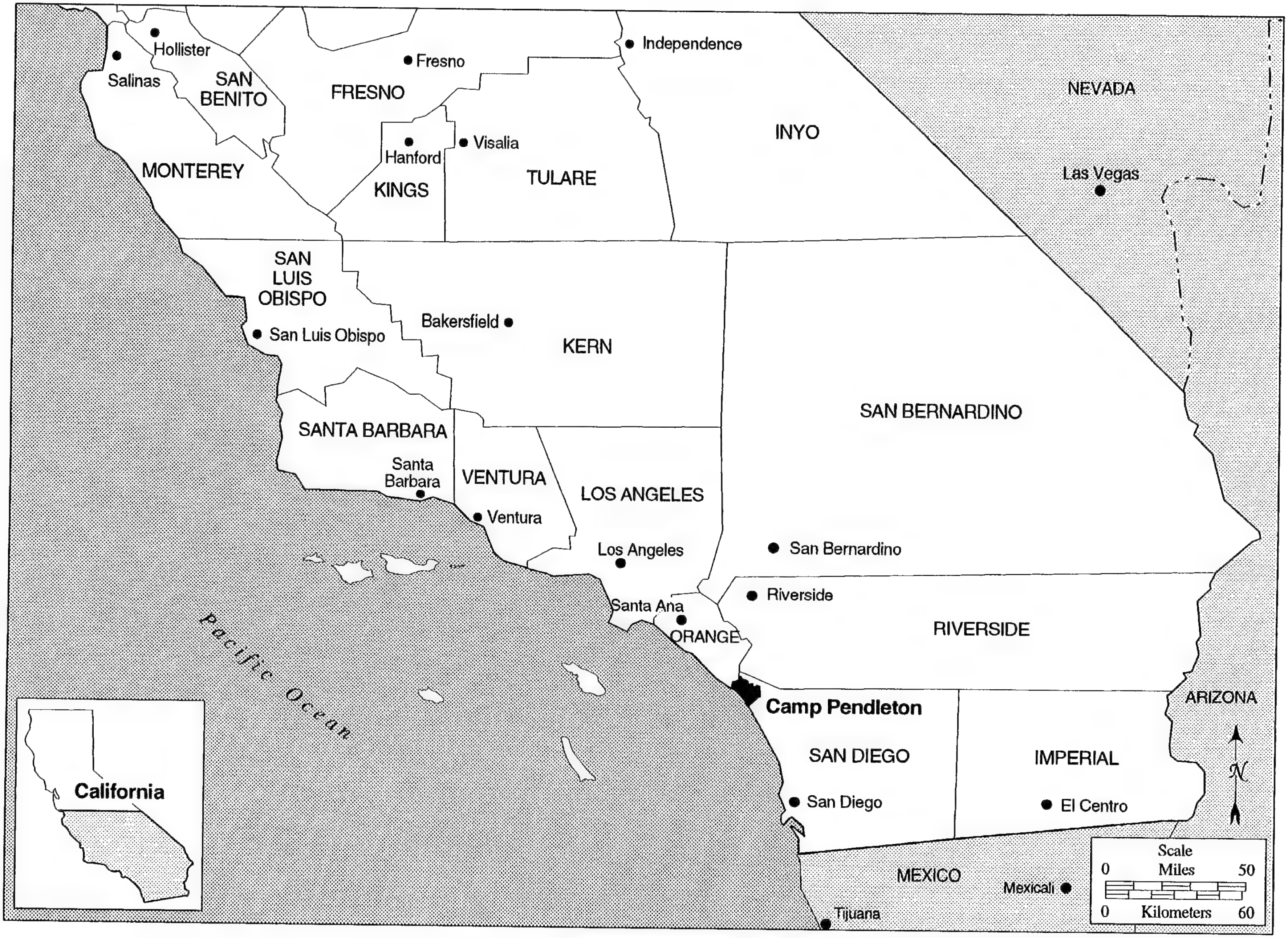

Figure 1-1. Regional Location of the Project

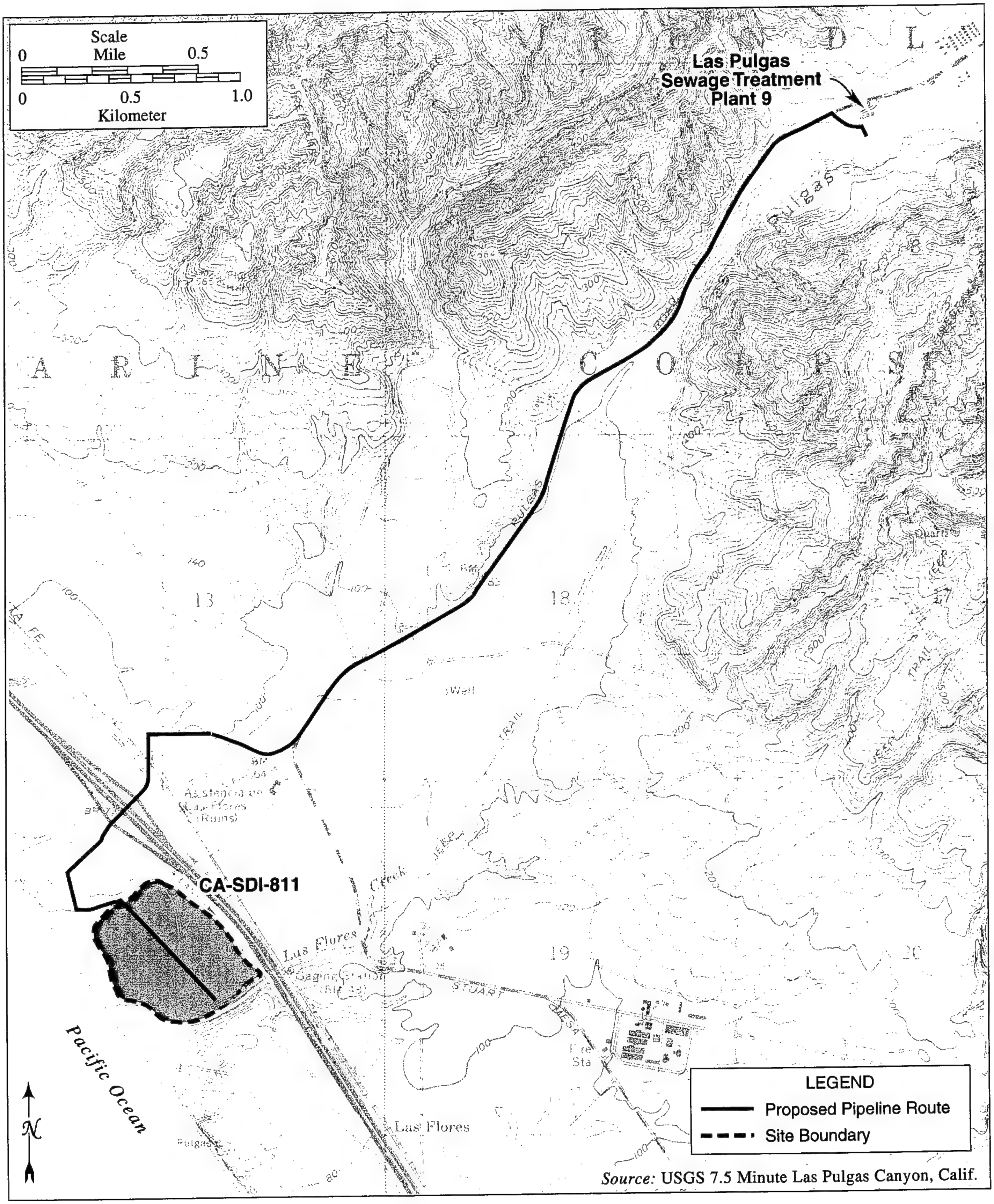

Figure 1-2. Location of the Proposed Pipeline and CA-SDI-811

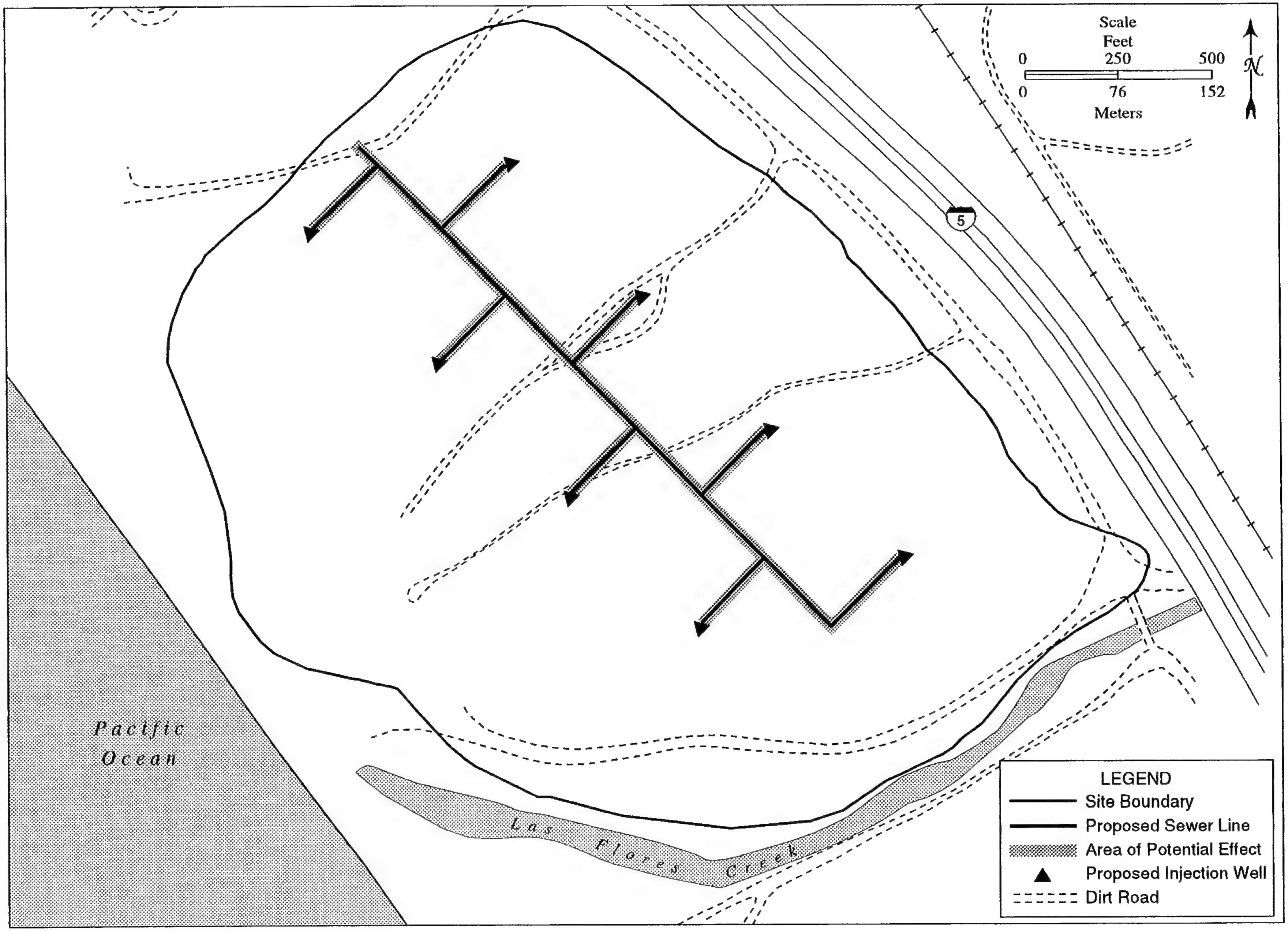

Figure 1-3. Pipeline and Area of Potential Effect at CA-SDI-811

1.3 PREVIOUS ARCHAEOLOGICAL INVESTIGATIONS

CA-SDI-811 (Red Beach Site)

SDI-811 was originally recorded as a scatter of three metates, 12 manos, and six dome scrapers observed on the surface approximately 100 m from the shoreline, along the north bank of the creek near a lagoon (California Parks and Recreation 1961). Subsequent archaeological investigations consisted of site visits during two surveys (Glenn and Crawford 1994:29; Kaldenberg 1982:31); excavation of 53 shovel test pits (STPs) and four units concentrated in the southeastern portion of the site (Byrd et al. 1996); and excavation of ten backhoe trenches in the northern portion of the site along the centerline of the proposed pipeline (Cagle et al. 1995). Byrd et al. (1996) focused on evaluating the NRHP eligibility of the site while SAIC's work was conducted to determine whether previously untested portions of the site contained significant archaeological deposits. On the basis of these investigations, the site has been determined to be eligible for listing on the NRHP based on criterion "d" of 36 CFR 60.4. The portions of SDI-811 within the project APE contain a variety of intact cultural deposits that exhibit intra-site spatial variability of artifactual and ecofactual material. As such, these portions of the site can contribute important information about the prehistory and history of southwestern California, particularly the poorly documented coastal areas of Camp Pendleton (Byrd et al. 1996; Cagle et al. 1995).

Figure 1-5 shows the location of areas excavated by Byrd et al. (1996) and SAIC (Cagle et al. 1995). The former investigation was located in the southern portion of the site, centered in an area of high density intact midden as is reflected in the artifact and shellfish densities. The SAIC investigation took place in the northern portion of the site, in an area with low density surface and subsurface materials. These investigations indicated some intra-site spatial variability in material discard patterns. The material densities do not drop off steadily as one proceeds northward away from the dense midden area; rather, patchy distributions of debitage, shell, and other faunal remains suggest possible activity areas or temporally discrete occupations. Table 1-1 summarizes the distribution of artifact densities at SDI-811 reported from the two investigations.

The tested areas of the project APE appear to retain good integrity, despite the effects of a variety of natural and cultural disturbances. In general, plowing has mixed cultural materials on the surface and in the upper deposit (0-40 cm), while deeper deposits (40-100 cm) have received little or no disturbance. Several dirt roads created by tank travel have removed or disturbed the uppermost cultural deposits, and historic farming activities such as disking and plowing have created "plowzones" and slightly compacted surficial cultural deposits. Site disturbances from natural processes are primarily bioturbation and erosion. Krotovina (rodent burrows) appear throughout the deposit. Despite such disturbances, the site retains sufficient vertical and horizontal structure to address a wide range of research questions.

Figure 1-4. Overview of the Red Beach Site looking Northwest

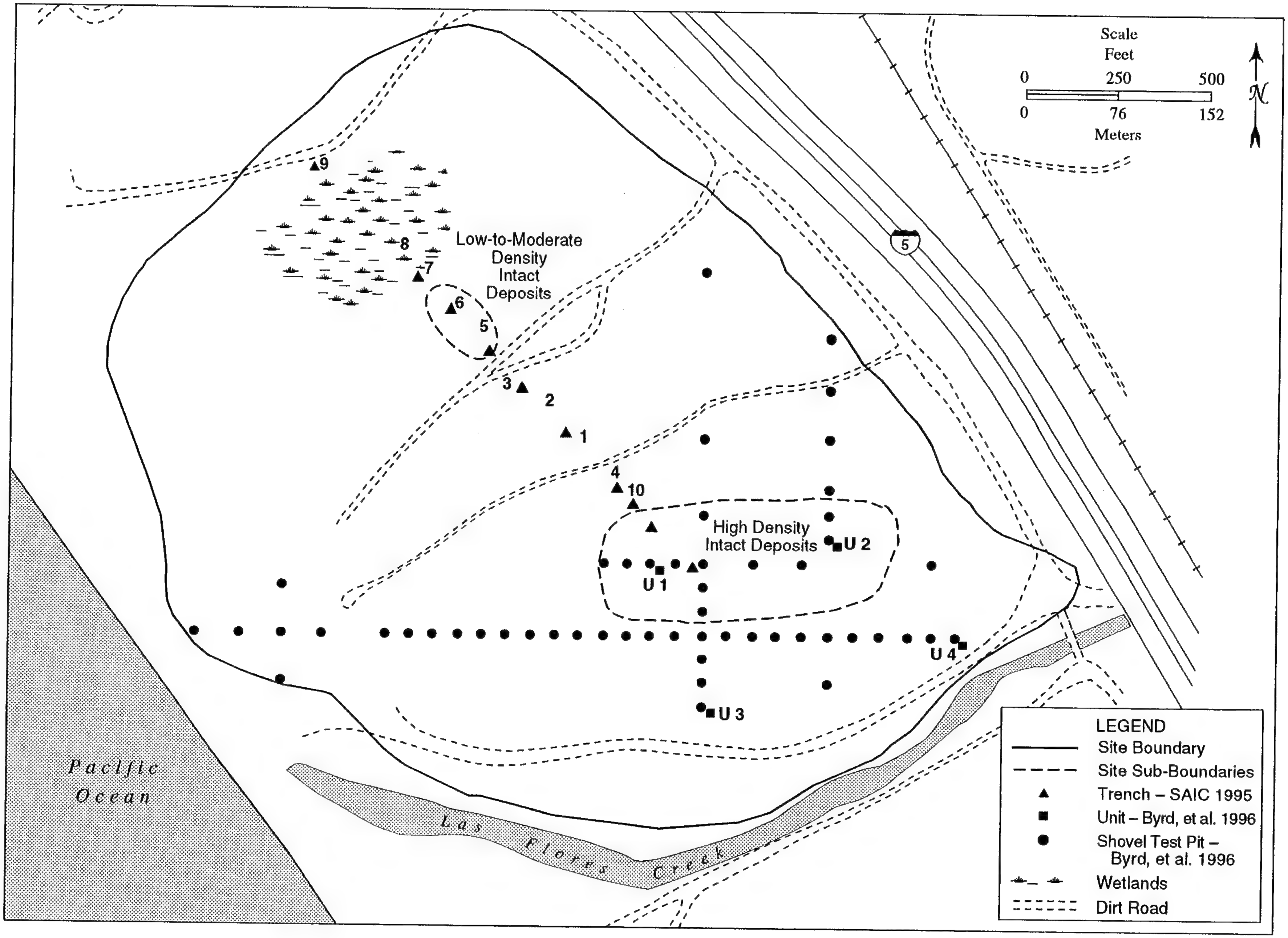

Figure 1-5. Location of Previous Archaeological Excavations at CA-SDI-811

Table 1-1. Distribution of Artifact Densities from CA-SDI-811

	BYRD ET AL. 1996				CAGLE ET AL. 1995			
	Unit 1	*Unit 2*	*Unit 3*	*Unit 4*	*Column T-4*	*Column T-5*	*Column T-6*	*Column T-10*
Volume excavated (m^3)	1.1	0.55	0.4	0.3	0.0375	0.0625	0.0625	0.05
Faunal (g/m^3)	163	74	2	3	277	29	5	2
Shell (g/m^3)	9,624	10,336	2,007	997	16	888	11	34
Debitage (ct/m^3)	292	305	10	30	800	32	16	60
Cores (ct/m^3)	P	P	NP	NP	NP	NP	NP	NP
Stone tools (ct/m^3)	P	P	NP	P	NP	NP	NP	NP
Groundstone (ct/m^3)	NP	P	NP	NP	P	NP	NP	P

Note: P present
NP not present

Additional Sites in the Las Flores Creek Area

The occupation at SDI-811 should be evaluated in conjunction within the other archaeological sites located with the Las Flores Creek area. A brief description of each site is provided below in order to demonstrate the types of sites discovered within the vicinity and the temporal range of occupation. To date, eight archaeological sites have been tested from the Las Flores Creek drainage area (Figure 1-6). In addition to SDI-811, these include SDI-812/H, -4536, -10723, -10726, -10728, -10731, and -14482. Table 1-2 provides a list of radiocarbon dates recovered from the Las Flores Creek sites.

SDI-812/H (Figure 1-6) is an aboriginal occupation area with several archaeological concentrations as well as a historic ranch house (Cagle et al. 1996a, 1996b; Glenn and Crawford 1994). Two historic structures are associated with the site, the ruins of Las Flores *Estancia* and the Las Flores Adobe (ranch house). Both buildings are listed on the NRHP. In addition, the Las Flores Adobe is a State Historic Landmark. The earliest component of the site dates to the Late Prehistoric/Ethnohistoric periods, with radiocarbon dates around A.D. 1500 to 1800 (Table 1-2).

The material dating to this time period comes from a buried component within Locus C, approximately 140-180 cm below the surface. The buried component has high density and high diversity of cultural material, including bifaces and other flaked stone material, vertebrate remains, marine shell, and prehistoric pottery. The animal bone is dominated by rabbits and other small game while the invertebrate assemblage consists primarily of *Donax*. The deposits appear to represent a pre-contact Luiseño residential base (Cagle et al. 1996b). The archaeological deposits from SDI-812/H have been determined eligible for listing on the NRHP (Cagle et al. 1996b).

SDI-4536 (Figure 1-6), the Las Flores Cemetery Site, was discovered in 1973 during construction of a wildlife sanctuary (Bull 1975; Ezell 1975). Subsequent testing documented

the existence of 14 human burials, four hearth cobble features, and a buried cultural midden deposit containing flaked stone artifacts, stone bowls, pestles, mortars, shellfish, and projectile points (Ezell 1975). A recent review of the data (Carrico 1996) suggests that the burials date to the Late Prehistoric period. According to Ezell (1975:6-7, 12), all of the burials were re-interred at the site; however, the NAGPRA inventory from the San Diego State University lists the remains of 14 individuals from this site at their facility.

SDI-10723 (Figure 1-6) is a Late Prehistoric site that includes a dense midden area and a low density scatter of shellfish remains (Cagle et al. 1996a). Material remains recovered from the site include chert and felsite debitage, mammal and bird bone, brownware pottery, groundstone, a Late Prehistoric projectile point, and fire-affected rock (Cagle et al. 1996a). No determination for eligibility has been made for this site.

SDI-10726 (Figure 1-6), the Las Flores Ridgetop site, is a moderately sized site composed of at least two different spatial components (Byrd et al. 1996). Locus A contains material from a Late Prehistoric occupation, including moderate densities of *Donax* shell, flaked stone artifacts, groundstone, and fire-affected rock. Locus B, the larger and more complex component of the site, contained at least one cobble hearth feature as well as a dense and diverse range of associated cultural material (Byrd et al. 1996). Deposits in Locus B appear to contain cultural material from both the early Archaic as well as the Late Prehistoric periods. The Ridgetop site is considered eligible for the National Register of Historic Places (Byrd et al. 1996).

SDI-10728 (Figure 1-6) is a multicomponent Early Archaic/Late Prehistoric site located on the south ridge overlooking Las Flores Creek. A diverse range of cultural material was recovered from the site, including flaked stone artifacts, groundstone, shell beads, ceramics, shellfish, and animal bone (Byrd et al. 1997). The site is considered significant based on its potential for addressing research questions about California, especially the coastal area of Camp Pendleton, and, therefore, has been recommended as eligible for the NRHP (Byrd et al. 1997).

SDI-10731 (Figure 1-6) is primarily a *Donax* shell scatter with associated artifacts (Bull 1975; Byrd et al. 1996). Two human burials were discovered during grading (Bull 1975). No detailed report was prepared during the grading project and the disposition of the human remains is unknown, but condition evaluation concluded that although the site has been heavily impacted by construction activities and recent flooding, intact buried deposits probably still exist at the site (Byrd et al. 1996).

SDI-14482 (Figure 1-6), previously designated as LP-1 and LP-2, was identified during a surface survey of the P529 project APE by MCB archaeologists, E. Ericson and D. Huey (personal communications 1995). LP-2 consists of redeposited site material, while LP-1 contains a small portion of intact cultural midden (Cagle et al. 1996a). The midden contains shellfish, debitage, and sparse animal bone. The site appears to date to Late Prehistoric times (Cagle et al. 1996a). No determination for eligibility has been made for this site.

Table 1-2. Radiocarbon Dates from Las Flores Creek Area
(page 1 of 2)

Site	*Provenience*	*Material*	*Beta #*	*Conventional C-14 Age*	*Calibrated Results (2 Sigma)*	*Reference*
Las Flores Creek Profile	Unit IV—100 cm	Low carbon sediment	75375	1800±80 B.P.	cal A.D. 60-420	Byrd et al. 1996
Las Flores Creek Profile	Unit IIIb—170 cm	Low carbon sediment	76432	2610±80 B.P.	cal B.C. 905-515	Byrd et al. 1996
Las Flores Creek Profile	Unit Ib—370 cm	Low carbon sediment	75376	4230±60 B.P.	cal B.C. 2920-2610	Byrd et al. 1996
CA-SDI-811	Unit 1, 40-80 cm	Shell (*Donax* spp.)	84170	1725±70 B.P.	cal A.D. 565-815	Byrd et al. 1996
CA-SDI-811	Unit 1, 70-80 cm	Shell (*Donax* spp.)	76211	1560±50 B.P.	cal A.D. 730-970	Byrd et al. 1996
CA-SDI-811	Unit 2, 80-90 cm	Shell (*Donax* spp.)	76212	1740±80 B.P.	cal A.D. 530-820	Byrd et al. 1996
CA-SDI-812/H	Locus A—STP 43, 20-40 cm	Shell (*Donax* spp.)	86597	580±60 B.P.	cal A.D. 1845-1950	Cagle et al. 1996b
CA-SDI-812/H	Locus A—STP 44, 20-40 cm	Shell (*Donax* spp.)	86598	680±50 B.P.	cal A.D. 1705-1950	Cagle et al. 1996b
CA-SDI-812/H	Locus C—unit 13, 20-30 cm	Shell (*Donax* spp.)	89382	630±60 B.P.	cal A.D. 1740-1950	Cagle et al. 1996b
CA-SDI-812/H	Locus C—unit 13, 50-60 cm	Shell (*Donax* spp.)	89379	720±60 B.P.	cal A.D. 1675-1950	Cagle et al. 1996b
CA-SDI-812/H	Locus C—unit 14, 70-80 cm	Shell (*Donax* spp.)	89378	750±60 B.P.	cal A.D. 1660-1950	Cagle et al. 1996b
CA-SDI-812/H	Locus C—unit 14, 90-100 cm	Shell (*Donax* spp.)	89374	640±50 B.P.	cal A.D. 1800-1950	Cagle et al. 1996b
CA-SDI-812/H	Locus C—unit 15, 30-40 cm	Shell (*Donax* spp.)	89384	730±60 B.P.	cal A.D. 1670-1950	Cagle et al. 1996b
CA-SDI-812/H	Locus C—unit 17, 60-70 cm	Shell (*Donax* spp.)	89381	630±60 B.P.	cal A.D. 1740-1950	Cagle et al. 1996b
CA-SDI-812/H	Locus C—unit 19, 140-150 cm	Shell (*Donax* spp.)	89385	830±60 B.P.	cal A.D. 1550-1890	Cagle et al. 1996b
CA-SDI-812/H	Locus C—unit 19, 170-180 cm	Shell (*Donax* spp.)	89380	870±60 B.P.	cal A.D. 1515-1835	Cagle et al. 1996b
CA-SDI-812/H	Locus C—unit 19-190-200 cm	Shell (*Donax* spp.)	89383	910±70 B.P.	cal A.D. 1475-1815	Cagle et al. 1996b
CA-SDI-812/H	Locus D—unit 38, 20-30 cm	Shell (*Donax* spp.)	89376	800±60 B.P.	cal A.D. 1620-1950	Cagle et al. 1996b
CA-SDI-812/H	Locus D—unit 38, 40-50 cm	Shell (*Donax* spp.)	89377	820±60 B.P.	cal A.D 1580-1950	Cagle et al. 1996b
CA-SDI-812/H	Locus E—unit 24, 90-100 cm	Shell (*Donax* spp.)	89375	660±60 B.P.	cal A.D. 1705-1950	Cagle et al. 1996b
CA-SDI-10,723	STP 4, 0-20 cm	Shell (*Donax* spp.)	86594	1080±70 B.P.	cal A.D. 1370-1645	Cagle et al. 1996a

Table 1-2. Radiocarbon Dates from Las Flores Creek Area
(page 2 of 2)

Site	*Provenience*	*Material*	*Beta #*	*Conventional C-14 Age*	*Calibrated Results (2 Sigma)*	*Reference*
CA-SDI-10,723	SPT 10, 0-20 cm	Shell (*Donax* spp.)	86595	850±50 B.P.	cal A.D. 1550-1835	Cagle et al. 1996a
CA-SDI-10,723	STP 10, 40-60 cm	Shell (*Donax* spp.)	86596	1230±60 B.P.	cal A.D. 1275-1460	Cagle et al. 1996a
CA-SDI-10,726	Locus A—unit 1, 70-80 cm	Shell (*Donax* spp.)	76215	1270±70 B.P.	cal A.D. 1015-1285	Byrd et al. 1996
CA-SDI-10,726	Locus A—unit 1, 70-80 cm	Charcoal	84167	290±70 B.P.	cal A.D. 1450-1685	Byrd et al. 1996
CA-SDI-10,726	Locus B—unit 5, 10-20 cm	Shell (*Donax* spp.)	76216	810±70 B.P.	cal A.D. 1420-1660	Byrd et al. 1996
CA-SDI-10,726	Locus B—unit 5, 60-70 cm	Shell (*Chione* spp.)	76217	6750±90 B.P.	cal B.C. 5435-5100	Byrd et al. 1996
CA-SDI-10,726	Locus B—unit 5, 60-70 cm	Charcoal	76218	1090±50 B.P.	cal A.D. 875-1025	Byrd et al. 1996
CA-SDI-10,726	Locus B—unit 5, 90-100 cm	Shell (*Chione* spp.)	84166	6870±80 B.P.	cal B.C. 5520-5245	Byrd et al. 1996
CA-SDI-10,728	Locus A—unit 3, 0-10 cm	Shell (*Chione* spp.)	92913	7720±80 B.P.	cal B.C. 6065-5845	Byrd et al. 1997
CA-SDI-10,728	Locus A—unit 3, 30-40 cm	Shell (*Chione* spp.)	91243	7420±80 B.P.	cal B.C. 5845-5510	Byrd et al. 1997
CA-SDI-10,728	Locus A—unit 3, 60-77 cm	Shell (*Chione* spp.)	91244	7980±90 B.P.	cal B.C. 6415-6000	Byrd et al. 1997
CA-SDI-10,728	Locus A—unit 3, 70-93 cm	Shell (*Chione* spp.)	92914	7590±90 B.P.	cal B.C. 5980-5655	Byrd et al. 1997
CA-SDI-10,728	Locus A—unit 5, 0-10 cm	Shell (*Donax* spp.)	92915	1280±60 B.P.	cal A.D. 1230-1435	Byrd et al. 1997
CA-SDI-10,728	Locus A—unit 5, 40-50 cm	Shell (*Donax* spp.)	92917	1240±60 B.P.	cal A.D. 1265-1455	Byrd et al. 1997
CA-SDI-10,728	Locus A—unit 5, 40-50 cm	Shell (*Chione* spp.)	29216	6570±80 B.P.	cal B.C. 5055-4665	Byrd et al. 1997
CA-SDI-10,728	Locus B—unit 1, 20-30 cm	Shell (*Donax* spp.)	91245	1000±60 B.P.	cal A.D. 1435-1675	Byrd et al. 1997
CA-SDI-10,728	Locus B—unit 2, 20-30 cm	Shell (*Donax* spp.)	91246	1090±60 B.P.	cal A.D. 1375-1600	Byrd et al. 1997
CA-SDI-14,482	SPT 15, 60-80 cm	Shell (*Donax* spp.)	86599	970±50 B.P.	cal A.D. 1460-1680	Cagle et al. 1996a
CA-SDI-14,482	STP 15, 140-160 cm	Shell (*Donax* spp.)	86600	1160±50 B.P.	cal A.D. 1320-1490	Cagle et al. 1996a

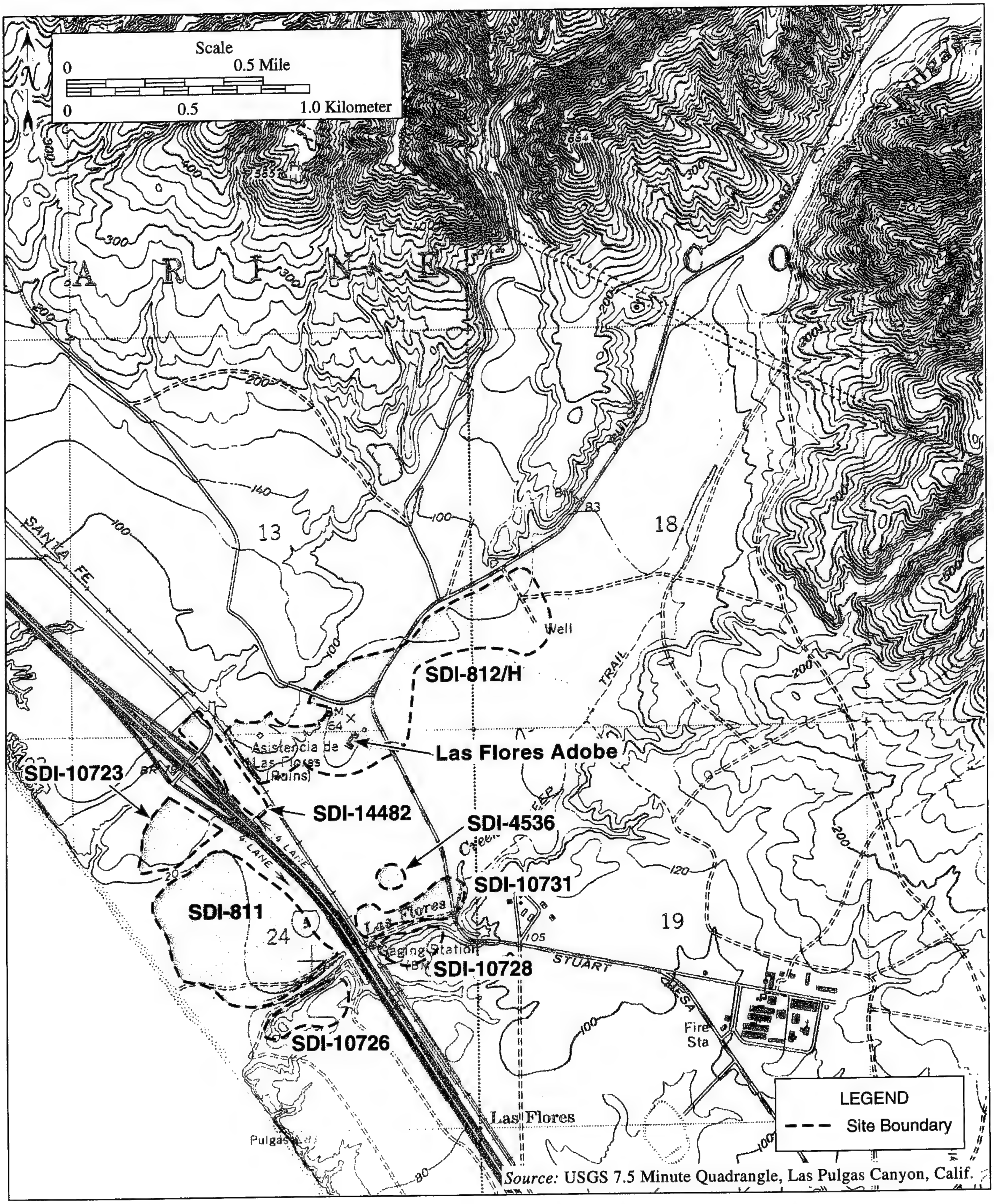

Figure 1-6. Location of Archaeological Sites in the Las Flores Creek Area

Additional Sites from San Onofre and San Mateo Creeks

Additional sites in the San Onofre and San Mateo Creeks are mentioned in the following chapters, including SDI-1074, -4411, and -13325 (Figure 1-7). SDI-1074 is a relatively large site in the San Onofre area, portions of which now lie under I-5. Radiocarbon samples indicate that it dates to about 600 B.P. (cal A.D. 1280 - 1430), which would place it in the later part of the Late Prehistoric period, but it may also include an ethnohistoric village site. The artifactual assemblage recovered during a recent testing project (Byrd et al. 1995) included debitage, cores, a few unifacially retouched tools, a Cottonwood Triangular projectile point base, percussing tools (i.e., hammerstones and choppers), and a couple of manos. The site produced only a few vertebrate faunal remains, but invertebrates were common. Littleneck clams (*Protothaca staminea*) were the most common species by weight, followed by *Tegula* spp. and bean clam (*Donax gouldii*). Site size and the diversity of artifacts indicate that this site was probably a base camp, and the faunal remains indicate a spring to early fall occupation (Byrd et al. 1995).

SDI-4411 (Figure 1-7) is a somewhat smaller site at the base of the ridge north of San Onofre, placing it only 0.15 mile (0.25 km) north of SDI-1074. A single charcoal sample from the site produced a date of 490 ± 60 B.P. (cal A.D. 1400 - 1510), indicating that this site also dates to the end of the Late Prehistoric period. Artifacts recovered during a testing project (Byrd et al. 1995) included debitage, cores, utilized flakes, percussing tools, a single unifacially retouched tool, and a biface fragment made out of Piedra de Lumbre (PDL) chert. Vertebrate faunal remains were more common in this site than SDI-1074, but the same three shellfish species dominate at this site (i.e., *Protothaca, Tegula,* and *Donax*). The relatively small size of the site and the less diverse artifact assemblage demonstrate that SDI-4411 was occupied for short periods, but it may have been used during multiple seasons (Byrd et al. 1995).

SDI-13325 (Figure 1-7), which is just north of I-5 in the lower part of the San Mateo drainage, is the largest of the sites considered here. Radiocarbon dates on both charcoal and shell cover a wide range of time, from cal 2310-1910 B.C. to cal A.D. 440-700, bridging the end of the Archaic period and the beginning of the Late Prehistoric. In addition to the artifact classes found at the previous two sites, SDI-13325 produced stone beads, shell beads, shell fishhooks, and a single fragment of Tizon Brownware. Both marine and terrestrial faunal remains were found in the site. While *Protothaca* and *Tegula* remained the most common shellfish species by weight, mussels (*Mytilus* spp.) were more common in this site than *Donax*. All indicators point to SDI-13325 as being "a residential base camp that was occupied for an extended period each year" (Byrd et al. 1995:173).

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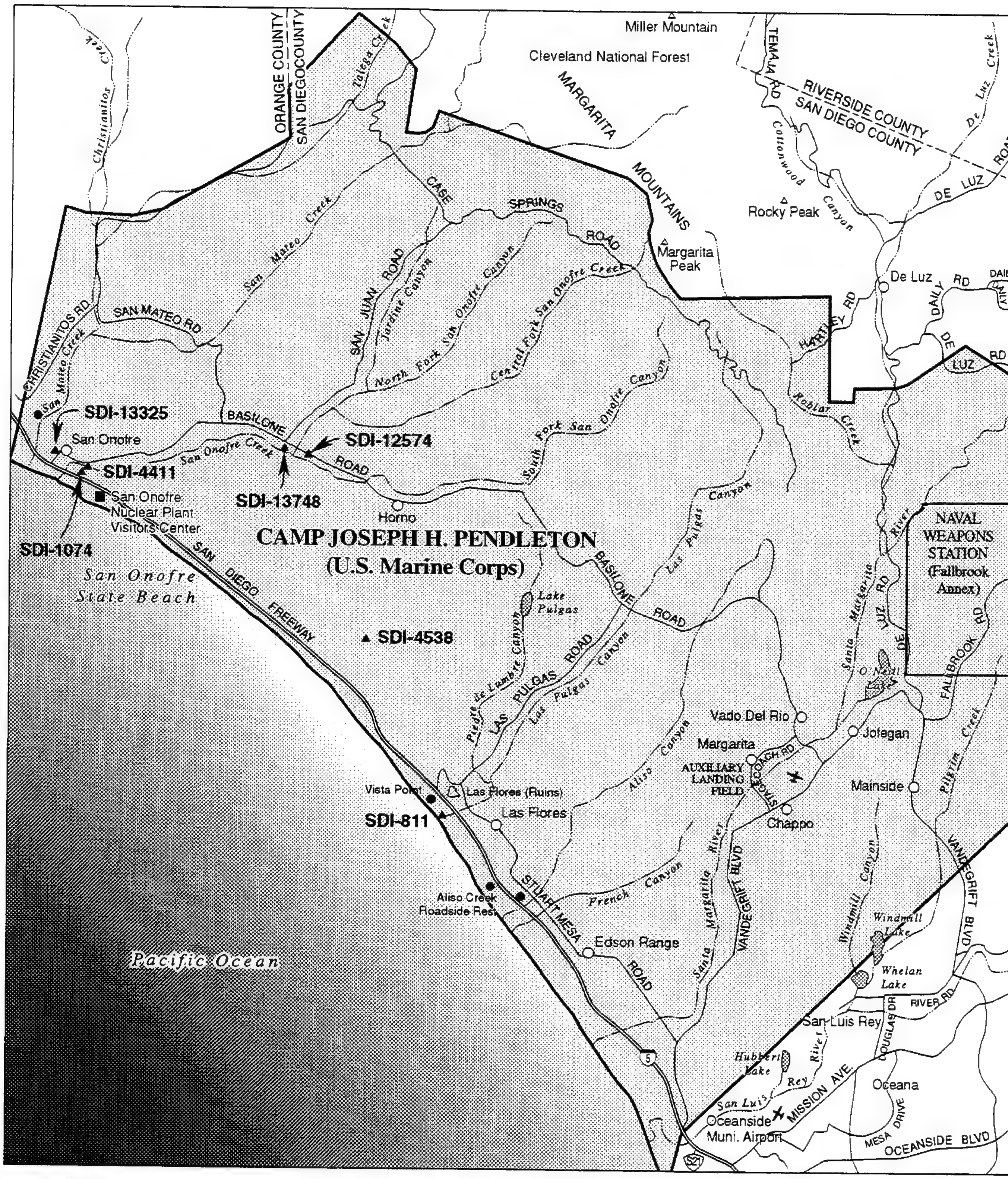


Figure 1-7. Location of Additional Archaeological Sites on Camp Pendleton

2 ECOLOGICAL AND CULTURAL SETTING

Karen A. Rasmussen

2.1 ENVIRONMENTAL SETTING

SDI-811 is located on Camp Pendleton in northern San Diego County, California. The site is situated on the floodplain of Las Flores Creek (see Figure 1-6) in the lower reaches of Las Pulgas Canyon, within 0.1 mile from the Pacific Ocean. The site ranges in elevation from approximately 10 to 40 feet above mean sea level.

Climate

Present day climatic conditions are typical of those for the Southern California coast. The climate is classified as xeric, with cool, wet winters and warm, dry summers. Average precipitation along the coastal zone is 32 cm per year (Palmer 1990) and mean annual temperature ranges from 15 to 22 degrees Celsius. Based on various historical observations, variability of precipitation and temperature appear to be moderately high over the time period of decades to centuries. Winter storms (November to April) account for the majority of rainfall, with the balance due primarily to occasional summer tropical storms. During the winter precipitation events, the frequency of storms and storm strength directly influence flood stage (peak) flow within the local creeks. These drainages, therefore, have low base-flow and high peak discharge. Seasonal coastal fog and moderate afternoon onshore breezes are common.

Vegetation

Modern plant communities within Camp Pendleton include grassland, chaparral, oak savanna, coastal sage, limited riparian, and improved areas (Hickman 1993; Munz 1974; Palmer 1990). Coastal sage scrub, such as California sagebrush (*Artemisia californica*), buckwheat (*Eriogonum fasciculatum*), woolly sunflower (*Eriophyllum lanatum*), white sage (*Salvia apiana*), black sage (*Salvia mellifera*), laurel sumac (*Malosma laurina*), squaw bush (*Rhus trilobata*), and sugar bush (*Rhus ovata*), predominates at SDI-811.

Fauna

A diversity of terrestrial, coastal, and marine species from a range of environmental zones were accessible from SDI-811. Native fauna typical of the project area include such

mammals as California ground squirrel (*Spermophilus beecheyi*), Botta's pocket gopher (*Thomomys bottae*), Audubon's cottontail (*Sylvilagus audubonii*), raccoon (*Procyon lotor*), ringtail (*Bassariscus astutus*), striped skunk (*Mephitis mephitis*), black-tailed deer (*Odocoileus hemionus*), various bat species (e.g., *Antrozous pallidus*), and possibly mountain lion (*Felis concolor*). A more detailed list of potential mammals living in the Northern San Diego County area, based on the range maps compiled by Jameson and Peeters (1988), is provided in Table 2-1.

In addition to mammals, Quail and migratory waterfowl, sea birds, and various types of reptiles can be found in the area. The site lies adjacent to a stretch of sandy beach, which supports a wide-range of sandy-shore invertebrates, such as bean clams (*Donax gouldii*). Other marine fauna typical of the project region include Venus clams (*Chione* spp.), oysters (*Ostrea lurida*), and scallops (Pectinidae) as well as rocky shore and kelp-bed dwelling fishes (e.g., croakers).

Geology

The project area lies within the northwestern portion of the Peninsular Ranges physiographic province of Southern California (Jahns 1954), which is bounded to the east by the Elsinore fault zone and to the west by the Pacific Ocean. The coastal plain of this physiographic province extends from the range front of the San Onofre Mountains to the modern coastline. The San Onofre Mountains are predominately underlain by the San Onofre Breccia, a Miocene conglomerate composed of blueschist, greenschist, quartzschist, mafic plutonic rocks, serpentinite, amphibolite, and sandstone clasts (Palmer 1990; Stuart 1979). These clasts erode out of the San Onofre Breccia and provide the majority of the cobbles found in the modern drainages.

The coastal plain comprises a sequence of Quaternary terrace surfaces cut into the Monterey Formation and San Mateo member of the Capistrano Formation. These formations, considered Middle Miocene and Late Miocene – Early Pliocene in age, are composed of sandy siltstone to mudstone, and sandstone to sandy conglomerate, respectively (Ehlig 1977).

Quaternary marine and non-marine deposits cap the terraces (Moyle 1973). Across the coastal plain, streams have incised their drainages into these elevated terraces, producing steep narrow canyons and broader valleys. In the vicinity of the site, the valley floor is approximately 0.7 km wide and relatively flat lying.

Within the area occupied by SDI-811, the valley fill predominantly consists of deposits of unconsolidated fine-grained fluvial sediments. Locally, coarse-grained (gravelly sand) sediments are present in minor amounts as stream channel deposits. Based on well log data, the valley fill thickness is estimated to range from 30 m in the center of the valley to 5 m along the margins of the valley floor (Palmer 1990). These deposits represent an aggradational sequence that records late Pleistocene-Holocene sea level rise and consequent deposition. The potential for preservation of buried cultural deposits within the valley fill sequence was previously recognized (Bornyasz and Rockwell 1996; Waters 1996).

Table 2-1. Mammals Living in Northern San Diego County

Cervidae (Deer)	**Leporidae** (Rabbits and Hares)
Odocoileus hemionus (Mule Deer)	*Lepus californicus* (Black-tailed Jackrabbit)
Canada (Dogs, Foxes)	*Sylvilagus audubonii* (Audubon's Cottontail)
Canis latrans (Coyote)	*Sylvilagus bachmani* (Brush Rabbit)
Felidae (Cats)	**Equidae** (Horses)
Felis concolor (Mountain Lion)	*Equus asinus* (Burro)—introduced
Mustelidae (Weasels, Martin)	*Equus caballus* (Horse)—introduced
Mephitis mephitis (Striped Skunk)	**Otariidae** (Sea Lions)
Mustela frenata (Long-tailed Weasel)	*Zalophus californianus* (California Sea Lion)
Spilogale putorius (Spotted Skunk)	**Phocidae** (Seals)
Procyonidae (Raccoons and Coatis)	*Phoca vitulina* (Harbor Seal)
Bassariscus astutus (Ringtail Cat)	**Arvicolidae** (Voles)
Procyon lotor (Raccoon)	*Microtus californicus* (CA Meadow Vole)
Phyllostomidae (Leaf-nosed Bats)	**Sciuridae** (Squirrels)
Macrotus californicus (CA Leaf-nosed Bat)	*Sciurus griseus* (Western Gray Squirrel)
Vespertilionidae (Vesper Bats)	*Spermophilus beecheyi* (CA Ground Squirrel)
Antrozous pallidus (Pallid Bat)	**Geomyidae** (Pocket Gophers)
Euderma maculatum (Spotted Bat)	*Thomomys bottae* (Botta's Pocket Gopher)
Plecotus townsendii (Townsend's Bat)	**Heteromyidae** (Kangaroo Rats, etc.)
Molossidae (Free-tailed Bats)	*Dipodomys agilis* (Pacific Kangaroo Rat)
Eumops perotis (Western Mastiff Bat)	*Perognathus californicus* (CA Pocket Mouse)
Nyctinomops femorosaccus (Free-tailed Bat)	*Perognathus fallax* (San Diego Pocket Mouse)
Soricidae (Shrews)	*Perognathus longimembris* (Pocket Mouse)
Notiosorex crawfordi (Desert Shrew)	**Cricetidae** (Deer Mice, Wood Rats)
Sorex ornatus (Ornate Shrew)	*Neotoma fuscipes* (Dusky-footed Wood Rat)
Talpidae (Moles)	*Neotoma lepida* (Desert Wood Rat)
Scapanus latimanus (Broad-footed Mole)	*Peromyscus boylii* (Brush Mouse)
	Peromyscus californicus (Parasitic Mouse)
	Peromyscus eremicus (Cactus Mouse)

Scientific nomenclature taken from Jameson and Peeters 1988.

Deposits within the site vicinity include the valley floor and floodplain, the terrace surfaces, and the terrace-to-valley slopes. Site-specific geology and soils stratigraphy are detailed in Appendix E.

Paleoecological Reconstruction

The Holocene era has been a time of rapid change in terms of the structure of paleocoastlines and the representation of local flora and fauna. The rapid sea level rise during the Late Pleistocene and Early Holocene created mainly rocky shorelines along the coastal zone of Camp Pendleton (Byrd et al. 1996; Inman 1983). When the rate of the rising ocean slowed during the last 4,000 years, large expanses of sandy beach replaced most of the rocky shorelines (Inman 1983). The abundance of many types of fish and shellfish would have changed depending on what habitats were available along the local shoreline. For example, archaeological sites in the area demonstrate the prevalence of *Donax* exploitation during the Late Holocene, but not before. *Donax* thrives in sandy-shore habitats and, according to

paleocoastline reconstructions, would not have become well established along Camp Pendleton until sometime after 4,000 years ago (Byrd et al. 1996:70).

In addition to changes in the structure of the coastline, palynological studies in the Las Pulgas Canyon have demonstrated considerable change in the local plant communities over the last 4,000 years (Byrd et al. 1996). Pollen evidence from the Las Flores Creek profile indicates that wetter conditions prevailed near the end of the Middle Holocene (Anderson 1996). These wetter conditions allowed cypress (*Cupressus)* or a similar type tree to thrive in the area, perhaps in a riparian environment. Approximately 2,600 years ago, various herbs colonized the area around the same time that the tree population appears to decline, suggesting an end to wetter climatic conditions. During the modern period, there was an influx of numerous non-native species, which replaced many indigenous plant communities (Byrd et al. 1996).

Overall, the various paleoecological changes during the Holocene would have had profound effect on the local hunters and gatherers because the types of flora and fauna available in the local region would have varied depending on the structure of local habitats at the time.

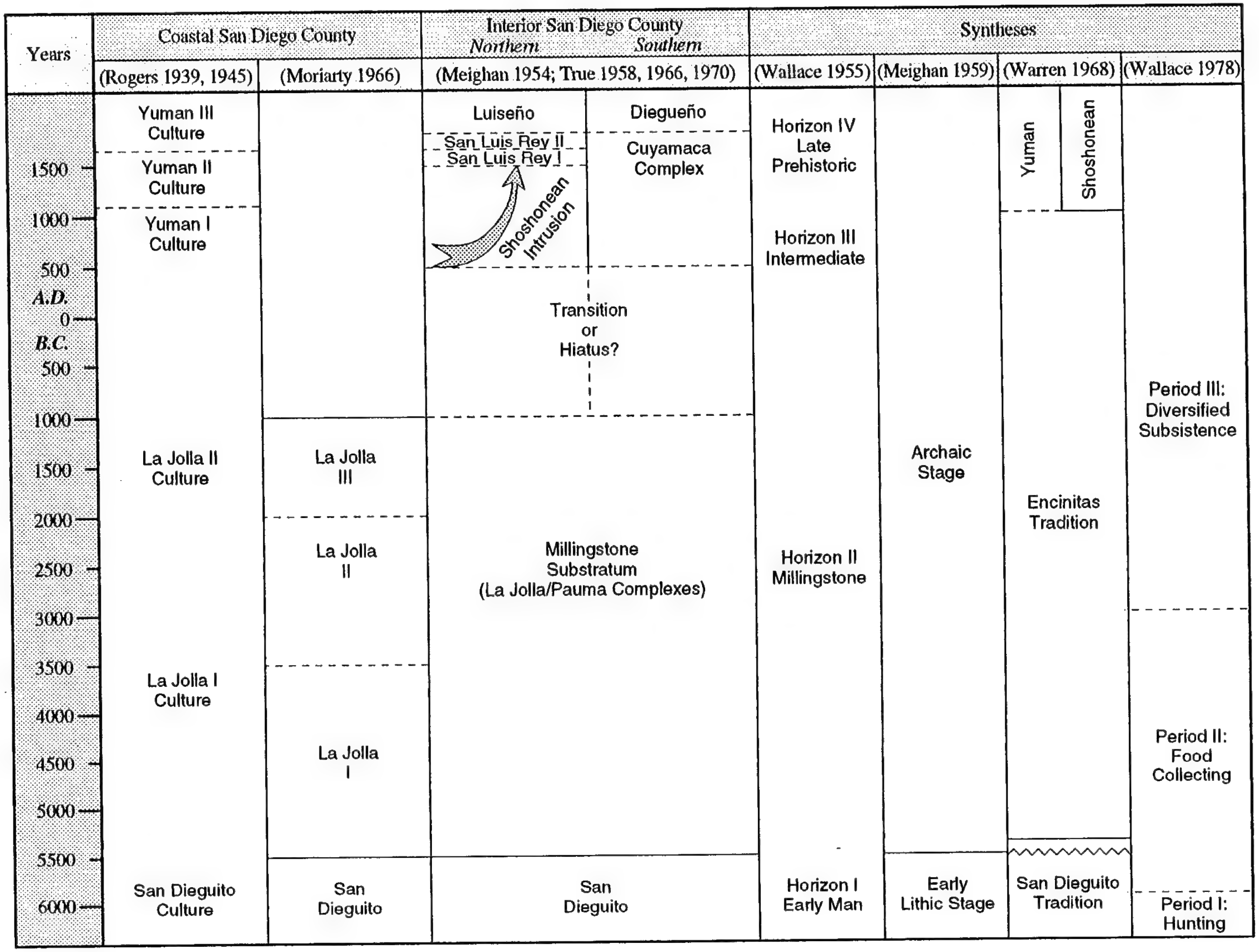
2.2 CULTURAL ENVIRONMENT

Prehistory of the Camp Pendleton Area

Various cultural sequences (Figure 2-1) have been defined for coastal California and San Diego County (e.g., Bull 1987; Ezell 1987; Moriarty 1966; Warren 1987), but none have been refined specifically for the Camp Pendleton region (Reddy and Byrd 1997). For consistency, this report will rely on a terminological sequence—Paleoindian, Archaic, Late Prehistoric—employed during other recent investigations in the Las Flores Creek locality (e.g., Byrd et al. 1996, 1997; Cagle et al. 1996b); however, our absolute dates for the three periods differ from some of the previous reports (i.e., Byrd et al. 1996, 1997).

The Paleoindian period, also known as the San Dieguito complex, dates from ca. 12,000 to 8,000 years before present (B.P.) and is typified by artifact assemblages consisting of typical hunter-gatherer flaked lithic tools, such as scrapers, scraper planes, choppers, and large projectile points (Davis et al. 1969; Moratto 1984; Warren 1987). A cooler and wetter climate during this period resulted in more wide-spread pinion-juniper and riparian plant communities. Sites occupied during this time suggest that the hunting of deer and smaller mammals was central to the San Dieguito economy. Typical Paleoindian assemblages do not contain millingstone technology.

Although no consensus has been reached among archaeologists, recent information suggests that the San Dieguito complex may have evolved into the La Jolla complex or Archaic Period between about 9,000 and 8,000 years B.P. (Erlandson 1994). This transitional period is supported by the presence of artifacts such as eccentric crescents and spire-ground *Olivella* beads in both complexes. One site that appears to demonstrate this relationship is SDI-210, a multi-component midden site located south of Carlsbad on the north shore of Agua Hedionda Lagoon (Moriarty 1967). In the upper levels, the nearly 2 m deep midden contained milling tools attributed to the La Jolla Complex. No millingstones were found



Source: Moratto 1984:158

Figure 2-1. Prehistoric Cultural Chronology for the San Diego Region

below 130 cm, but scrapers, choppers, and hammerstones typical of the La Jolla Complex were found throughout all levels of the midden and the soil profile exposed a homogeneous deposit lacking obvious stratification. A sample of shell from the base of the midden returned a radiocarbon date of 9020 ± 500 RYBP.

The Archaic period (La Jolla complex) lasted until approximately 2,000 years before present. During this period the subsistence focus changed from generalized hunting and gathering to an increased reliance on marine resources (primarily shellfish and fish). The majority of the La Jollan sites are located along the coast and major drainage systems extending inland and are characterized by the appearance of millingstone technology (basin metates and manos), shell middens, cobble tools, discoidals, a small number of Pinto and Elko series points, and flexed burials.

The Late Prehistoric period is characterized by the introduction of ceramics and changes in burial traditions and lithic technology. Flexed inhumations are replaced with cremation burials, and small pressure-flaked projectile points make an appearance. There is a shift from littoral resource exploitation to an emphasis on inland plant (especially acorns) food collection, processing, and storage. These changes are believed to be associated with a migration of Yuman-speaking people from the eastern Colorado River region around 2,000 B.P. (Rogers 1945) and Shoshonean speakers after 1,500 B.P. (Moratto 1984; True 1966). During this period, inland semi-sedentary villages were established along major water courses, and mountain areas were seasonally occupied to exploit acorns and piñon nuts.

In the northern part of San Diego County, the Late Prehistoric period is represented by the San Luis Rey complex (Meighan 1954; True et al. 1974), which is considered to represent the Shoshonean predecessors of the ethnohistoric Luiseño. The San Luis Rey complex is divided into two phases: San Luis Rey I, a preceramic phase lasting from ca. A.D. 1400-1750 (Meighan 1954; True et al. 1974) and San Luis Rey II, a ceramic phase correlating with the ethnohistoric period between A.D. 1750-1850 (Meighan 1954). The San Luis Rey II complex differs primarily in the appearance of cremation urns, ceramics, and red and black pictographs. Ceramics may have entered into the San Diego region as early as ca. A.D. 1200-1600 (True et al. 1974), but did not become common until the ethnohistoric period. In the southern portion of San Diego County, the Late Prehistoric period is characterized by the Cuyamaca complex (Moratto 1984), which shares many traits with the San Luis Rey complex. The Cuyamaca differs from the San Luis Rey complex in some of their mortuary practices, such as separating cemeteries from residential areas and the use of grave markers, as well as the presence of a steatite industry and numerous millingstones (True 1970).

Ethnohistoric Background

A wide range of historical, ethnohistorical, and ethnographic sources provide an outline of the ethnohistory of the Camp Pendleton region. Historical documents include the sacramental and census registers (*padrones*) of the Franciscan Missions as well as various documents from early explorers (e.g., Bolton's 1927 translation of the Crespí diary of the Portolá Expedition). A large body of ethnographic and ethnohistorical sources provide information on a wide range of topics including settlement, subsistence, social organization, population size, and cosmology of the people who lived in the Camp Pendleton region when

the Spanish arrived (e.g., Bean and Shipek 1978; Earle and O'Neil 1994; Harrington 1933, 1986; Johnson 1997; Kroeber 1925; McCawley 1995, 1996; Rivers 1991; Sparkman 1908). Despite the range of data available, a comprehensive ethnohistoric study has not yet been completed.

Cultural Affiliation

According to Kroeber's study (1925), Camp Pendleton straddles the boundary between the Native American Luiseño and Juaneño cultural groups (Figure 2-2). Both are Shoshonean speaking populations that inhabited what is now northern San Diego, southern Orange, and southeastern Riverside counties.

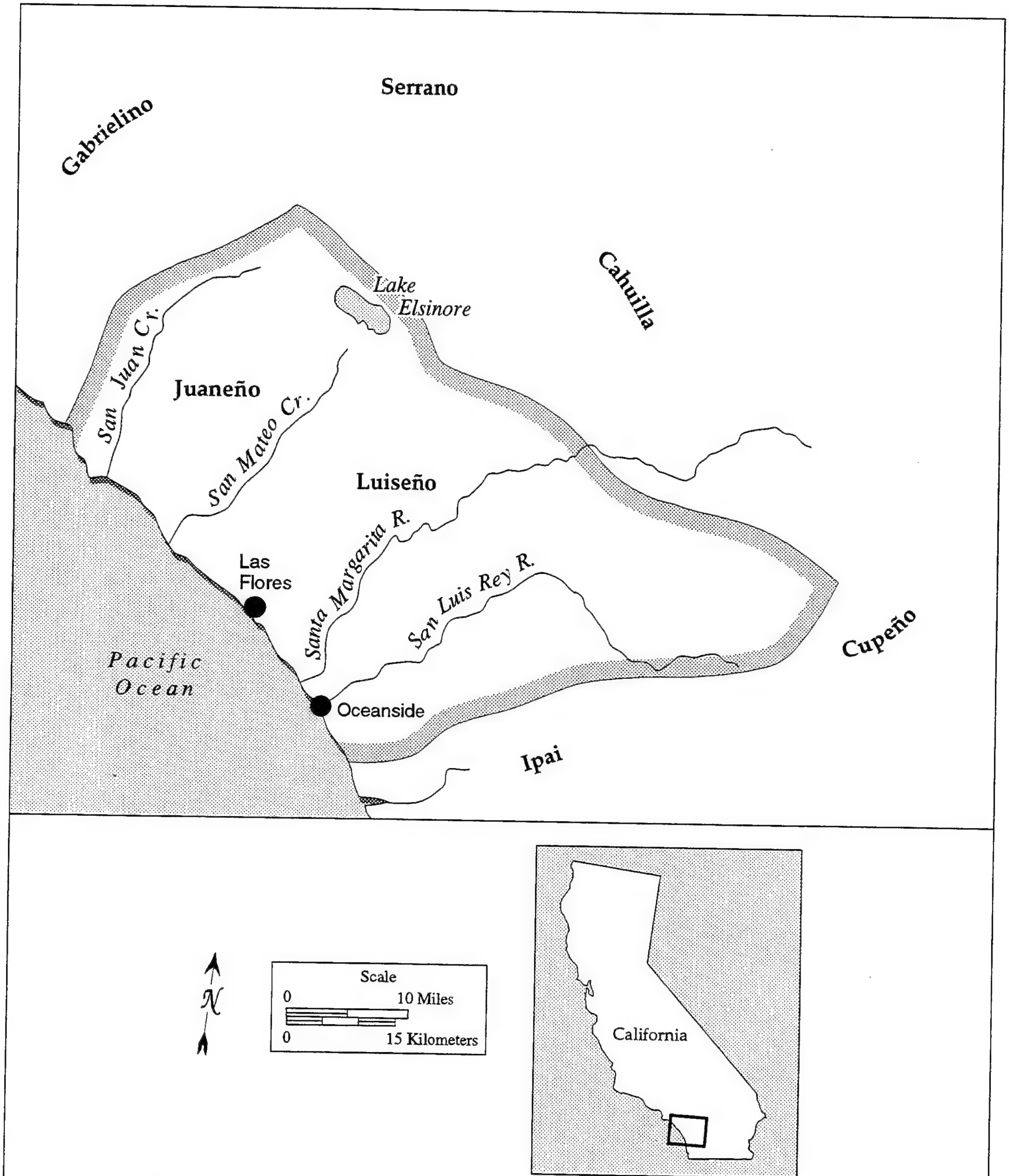
The Shoshonean inhabitants of northern San Diego County were called Luiseños by Franciscan friars, who named the San Luis Rey River and established the San Luis Rey Mission in the heart of Luiseño territory. Their territory encompassed an area roughly from Agua Hedionda Creek north to Aliso Creek on the coast, and inland to Santiago Peak and Palomar Mountain (Bean and Shipek 1978). The Luiseño shared boundaries with the Gabrielino and Serraño to the west and northwest, the Cahuilla from the deserts to the east, the Cupeño to the southeast, and the Ipai or Kumeyaay to the south. All but the Ipai are linguistically similar to the Luiseño, belonging to the Takic subfamily of Uto-Azetecan (Bean and Shipek 1978).

Less is known about the Juaneño, whose name derives from an association with the Mission San Juan Capistrano, founded in 1776. The territory ascribed to them by Kroeber extended from Aliso Creek on the north to the area between San Onofre and Las Pulgas drainages on the south, with the Pacific Ocean forming the western boundary and the crest of the Santa Ana Mountains forming the boundary on the east. Their neighbors on the east were the Gabrielino, and the Luiseño bordered them on the east, northeast, and south.

There is some controversy over the nature of the Juaneño as a group. Kroeber recognized Juaneño as a dialect of Luiseño, but treated the populations as separate peoples. Cameron (1987) supports this interpretation based on archaeological evidence, but Bean and Shipek (1978) and White (1963) treat the Juaneño as part of the Luiseño on the basis of cultural and linguistic similarities.

Social and Settlement Organization

The Luiseños were divided into several autonomous lineages or kin groups based on a patrilineal and patrilocal social system. The lineage represented the basic political unit among most southern Californian Indians. The exact nature of settlement dynamics of the Luiseño is still debated. According to Bean and Shipek (1978), the Luiseño exploited a wide range of resources in a bi-modal seasonal system. Most inland groups had fishing and gathering sites on the coast that they visited annually when the tides were low or when inland foods were scarce from January to March. The mountain camp was occupied by most of the village population during October and November when acorns were harvested and game animals hunted. Each lineage had exclusive hunting and gathering rights in their procurement ranges and trespassers were seriously punished (Bean and Shipek 1978).



Source: Bean and Shipek 1978:551

Figure 2-2. General Boundary of Ethnographic Groups

It has also been suggested that coastal Luiseño and Juaneño groups stayed along the seashore the entire year instead of utilizing the bi-modal system discussed above (Koerper 1981). Alternatively, Shipek (1977) suggests that during ethnohistoric times the Luiseño occupied permanent villages in a variety of ecological zones and made seasonal forays to procure specific resources from particular localities.

True and Waugh (1982) describe a diachronic model of settlement and subsistence change during the Late Prehistoric period of Luiseño occupation. They suggest that settlement patterns during approximately A.D. 1 to A.D. 1500 were characterized by small, briefly occupied campsites located in a variety of locations, a classic indication of what is now called a foraging strategy. After A.D. 1500, they suggest that settlement patterns became more territorial, focused on specific drainages, and reflect a collector-oriented strategy. Sites included permanent villages in the western foothills and permanent summer camps in the mountains.

Finally, Graham's (1981) model was proposed for Late Prehistoric Kumeyaay (Ipai) rather than Luiseño, but the fusion-fission dynamics of his model are relevant here. In his study area, he sees population aggregation in the mountains during summer and autumn to collect and store seasonally available grass seeds and acorns. Aggregation gives way in the winter as small groups move to the desert to forage for patchier, less abundant resources. This model suggests that Late Prehistoric groups practiced collecting as well as foraging strategies in response to seasonal variations in resource abundance and availability.

Subsistence Patterns

Acorns were an important food source to the Luiseño and Juaneño groups, as they were with most inland communities of Takic-speakers in southern California. Acorns were collected in the fall and then stored in either conical shaped granaries or in ceramic storage pots (McCawley 1995). It is unclear how important acorns were to the coastal inhabitants, but many researchers believe that these nuts may have composed up to 25 percent of the diet. Table 2-2 provides three different hypothetical breakdowns of the diet for the coastal Luiseño. Please note that the estimates made by Earle and O'Neil (1994) were centered on the coastal littoral communities in the Santa Ana River drainage, the Santa Ana and San Joaquin foothills, and the San Juan Capistrano area.

In the case of the Las Flores Creek study area, records from the 1769 Portolá expedition report some oak groves within the Las Pulgas Canyon (Earle and O'Neil 1994 from Bolton 1927). In addition, the coastal groups may have visited more interior areas during harvest time or may have exchanged goods with more inland residents in order to acquire enough acorns for the community.

Besides acorns, people utilized various seeds, greens, bulbs, roots, and fruits. This includes a wide variety of cacti and even edible reeds. The greens may have been an important springtime food, when other supplies were relatively scarce. Edible reeds could have provided a supplementary resource during food scarcity, such as late winter.

Table 2-2. Estimated Dietary Breakdown for the Coastal Luiseño

Resource	*White (1963)*	*Bean & Shipek (1978)*	*Earle and O'Neil (1994)*
Acorns	10-25%	15-25%	10-25%
Greens	5-10%	5-10%	5-10%
Bulbs, Roots, Fruits	10-15%	5-10%	10-15%
Seeds	5-10%	20-40%	minimum 20%
Game	5-10%	5-10%	*not given*
Fish & Marine Animals	50-60%	20-35%	around 35%

Bean and Shipek (1978) believe seeds provided a large bulk of the nutritional needs of the people. They mention the use of grass seeds, manzanita, sunflower, sage, chia, lemonade berry, wild rose, holly-leaf cherry, prickly pear, lamb's-quarters, and pine nuts.

The Luiseño hunted large and small terrestrial game, including black-tailed deer, antelope, jack rabbits, rabbits, various birds, grasshoppers, and rodents. Deer were hunted with bow and arrow, captured in snares, or driven off cliffs (McCawley 1995). Smaller mammals, such as the rabbits and rodents, were hunted with bow and arrows, throwing sticks, snares, traps, and draw nets. McCawley (1995) lists a series of animals that were not eaten by the Luiseño during pre-mission times. This list includes tree squirrels, wild pigeons or doves, dogs, coyotes, foxes, wolves, badgers, skunks, raccoons, wildcats, gophers, moles, eagles, buzzards, crows, hawks, owls, mockingbirds, lizards, snakes, rattlesnakes, turtles, tortoises, frogs, and toads.

Fish and other marine animals obviously played an important dietary role to the people living along the coast. Fishing equipment included bone and shell fishhooks, yucca fishing line, and detachable-point harpoons (McCawley 1995). In addition, coastal groups used dugout or rush bundled canoes (Earle and O'Neil 1994; Harrington 1986; McCawley 1995). Such crafts would have given the coastal inhabitants access to offshore fishing grounds. In addition to fish, the coastal groups subsisted off of a wide variety of locally available shellfish, marine mammals, and crustaceans (Bean and Shipek 1978).

Historical Times

First contact between the Europeans and the Luiseño came in 1769 with the arrival of Gaspar de Portola's expedition. The expedition was traveling between San Diego and Monterey in order to investigate possible Mission sites (Rivers 1991).

Mission San Juan Capistrano was established in 1776, the seventh of California's twenty-one missions. Mission San Luis Rey was founded 22 years later as the 18th mission (Rivers 1991). By 1830, the holdings of Mission San Luis Rey included San Onofre, Santa Margarita, San Marcos, Pala, Temecula, San Jacinto, Agua Caliente, and Las Flores (Brigandi 1982, revised 1995).

It has been estimated that there were 50 Luiseño villages, each with a population of about 200 people at the time of contact (White 1963) for a total population of 10,000. The mission records register 3,683 Luiseño in 1828 (Bean and Shipek 1978), indicating a drastic decrease. Earle and O'Neil (1994) have recently re-calculated population estimates based on Mission sacramental register information, and they suggest this decline was not quite as great. Whatever the case, few would argue that the Luiseño suffered a large decline in population from introduced European diseases as well as living conditions under the Mission system. Nevertheless, the Native American populations under the jurisdiction of the San Luis Rey Mission faired better than most California Mission communities (Hornbeck 1983; Jackson 1994; Johnson 1997).

The indigenous communities brought into the mission system were taught the Roman Catholic faith, Spanish language, farming skills, animal husbandry, adobe brickmaking, carpentry, and other European crafts (Bean and Shipek 1978). The policy at Mission San Luis Rey was to maintain the Luiseño settlement pattern, and priests visited the villages to hold masses, perform marriages, and supervise agricultural activities. Although, for the most part, traditional economic methods continued as the basic subsistence mode and leadership continued as it had always been, ethnohistoric data and new information from SDI-812/H indicate that a major cattle ranch operation was in place earlier than 1810 (Cagle et al. 1996b). The Mission's policy of less-direct or minimal interference was probably one of the reasons that the local communities in this area of California saw less devastating population decrease than in other mission communities. Nevertheless, the Luiseño's social and political organization was drastically and forever changed by the policies of missionization (McCawley 1995, 1996).

In 1834, the missions were secularized, resulting in political imbalance and Native American revolts and uprisings against the Mexican rancheros who used the local populations as serfs. In theory, this secularization was supposed to act as a transition from mission-controlled to Indian-controlled pueblos (McCawley 1996). This would also allow the missions to continue developing new territories in more inland areas while leaving the "christianized" Native Americans in charge of their original holdings. In reality, the secularization movement allowed self-aggrandizing individuals, mostly Mexican citizens, to control the wealth of vast amounts of lands. By 1845, Pio Pico, temporary governor of California and last governor of Mexican California, and his family acquired over 133,000 acres of land, including San Onofre, Santa Margarita, and Las Flores (Rivers 1991).

At this time, many Luiseño left the missions and sought refuge among inland groups while a few acquired land grants and entered into the mainstream Mexican culture. Several local pueblos were established for some of the San Luis Rey *rancherías*, among them Santa Margarita and Las Flores by the Mexican government. These pueblos were intended to be governmental units within the Mexican political system. Most disappeared, like Las Flores and Santa Margarita, under Mexican rancho rule.

3 RESEARCH DESIGN

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3.1 THEORETICAL APPROACH

Hunter/Gatherer Adaptation

The forager-collector continuum (Binford 1980, 1982) was developed to investigate the processes by which hunter-gatherers adapt to a changing environment. Rather than emphasizing empirical generalizations about hunter-gatherer settlements, this approach stresses strategies of adaptation and allows explanation of variability in settlement. Binford's basic proposition is that the organization of resource procurement can be characterized as a continuum of logistical complexity. Binford's distinction between foragers and collectors provides an important heuristic device for examining some of the dynamics inherent in prehistoric hunter-gatherer settlement organization (Reddy and Byrd 1997:62), especially in terms of the relationship between resource exploitation and settlement choice.

Binford placed *foragers* at the least complex end of the spectrum, with *collectors* at the most complex. A group may expediently select a collecting or foraging strategy (or any of the steps along the continuum) depending on environmental variables, such as the abundance of a resource that is dependent on the change of seasons.

A foraging strategy permits procurement of resources by moving the residential group from one resource patch to another and exploiting those resources within the general area of the camp (the *foraging radius*). At the more complex end of the continuum is a collecting strategy. Rather than acquiring resources by moving their residential group from one resource patch to another, collectors occupy base camps where they employ small, specially organized task groups to obtain resources elsewhere and bring them back to the main settlement. These task groups may establish temporary habitation sites or other specialized sites from which their procurement activities can be planned and executed.

Binford suggests that foraging and collecting strategies represent alternative solutions to different problems associated with the distribution of critical resources in the environment. Foraging strategies involve the movement of consumers to resources through residential moves, a strategy that can only be successful if all critical resources are located within a foraging radius of the base camp. Collectors, on the other hand, move resources to consumers, a necessary strategy when the distribution of critical resources is scattered: "Under conditions of spatial incongruity . . . a residential move will not solve the problem.

A move toward one location reduces the access to the others. It is under this condition that a logistical strategy is favored" (Binford 1980:15).

It is important to emphasize, as Binford does (1980), that (1) the distinction between foraging and collecting is a continuum, not a dichotomy, and (2) one group over time can select variations of these procurement strategies along this continuum. In other words, a large group might fragment into smaller groups to forage in the summer when resources throughout their territory are scarce, and they might regroup the larger unit to collect in the autumn when a few resources are abundant and accessible only in specific locations (Binford 1982). Longer-term shifts in climate and resource distributions would also result in changing strategies of resource procurement, which might include either more foraging or more collecting.

Binford states that the kind of mobility – logistical or residential – is determined by the distribution of critical resources. But when viewing adaptations in relation to the environment, it is most useful to discuss the structure of the environment rather than the actual species existing in it (Bamforth 1988; Thomas et al. 1979). The environmental structure – how resources are distributed in time and space – can be divided into patchiness (spatial distribution), predictability (temporal variability), and abundance (productivity) (Bamforth 1988). The division of the environment into these broad categories allows comparisons of adaptations between very different types of ecological zones. It further permits an examination of the effects of change in the environment through time.

Abundance is the total biomass of a resource in a region or habitat. Patchiness refers to the evenness of the distribution of resources. In a patchy environment resources are clumped or clustered, rather than evenly distributed. Predictability refers to changes in the availability of a resource. This aspect of predictability is also known as constancy – the degree of variability in space and time (Bamforth 1988).

One reason for examining the effects of different properties of the environment is that it allows us to predict modifications in long-term regional adaptations resulting from environmental changes. Depending upon the nature of the change, long-term environmental shifts may affect resource patchiness, predictability, and abundance depending upon the nature of the change. Minor long-term alterations in temperature or precipitation may have little effect on the composition of species, but may signal changes in the frequency of short-term variations (Flohn 1981) that can affect the productivity and predictability of resources.

Abundance, patchiness, or predictability can affect the settlement organization. For example, kinds of mobility (residential or logistical), storage, and degree of mobility (how often someone moves) are affected by different aspects of the environment. Residential or logistical mobility is related to patchiness – the degree of heterogeneity of the environment. Foraging strategies are most effective in a homogeneous environment where the foraging radius of a site is searched and resources exploited as they are encountered. Logistical strategies such as collecting, on the other hand, are most effective in a patchy environment. Task groups are sent to resource patches to extract and process resources, then bring them to the main settlement. Resources are not exploited as they are encountered, they are pursued. Stations (information gathering sites) provide the information necessary to pursue resources

efficiently. The patchier the environment the more logistical the adaptation will be. Very patchy environments require an elaborate organization to coordinate extracting, processing, and transporting resources back to the main group. A consequence of this logistical organization is that intersite variability increases — sites are more specialized and there are more kinds of sites in the organization as a whole (Binford 1980:12).

The need for storage, on the other hand, is affected by temporal instead of spatial variability of resources. A cache may be located in a certain area because it is too far away from the residential base to transport the resource efficiently, but its main purpose is to store resources that are available for a limited time. Storage of resources may occur with either foraging or collecting strategies depending upon the seasonal availability of resources. It is possible, however, that once a foraging society has begun to store resources, they may become less mobile and develop a logistical strategy to prevent moving. Testart (1982) argues that the act of storing an abundant, but seasonal resource actually prohibits groups from moving away from their stored resource.

The degree of mobility — the number of times a group moves — will be affected by the productivity or abundance of resources in an area. Theoretically, a foraging residential base camp could be occupied permanently if resources were sufficiently abundant (see Kelly 1992; Price and Brown 1985).

One other factor, population size, can have a major effect on settlement organization. Whether the productivity of resources is sufficient for survival depends upon the size of the group. An increase in group size may necessitate more frequent residential moves. As Binford points out (1980:17), the regional consequences of population increase may be to reduce mobility as the area becomes settled, which will in turn increase logistical production and may also increase the use of storage facilities.

Site Types

Binford's model is archaeologically useful because foraging and collecting strategies generate different types of archaeological sites that can be distinguished by varying combinations of manufacturing, extraction (e.g., hunting), maintenance (e.g., tool repair, house building), and processing (e.g., cooking) activities.

A foraging strategy produces two kinds of sites - residential base camps and locations (Binford 1980).

- The *residential base camp* is the center of the group's activities, with manufacturing, maintenance, and processing occurring there. Because of the large number of these activities and the generalized composition of social groups (all ages, both sexes), residential base camps tend to have a diverse range of artifacts and features.

- *Locations* are where resources are extracted, but maintenance, processing, and manufacturing are not conducted. Locations tend to be very temporary work places and few artifacts are discarded. Consequently, they are difficult to discern in the archaeological record.

In addition to residential base camps and locations, a collecting strategy produces a number of specialized procurement sites - field camps, stations, and caches.

- A *field camp* is a task group's temporary habitation site while away from the residential base group. Manufacturing, maintenance, and processing take place there, but the resources exploited tend to be limited.

- *Stations* are information gathering sites, such as hunting blinds. Limited manufacturing and maintenance activities may occur there.

- *Caches* are temporary storage areas for abundant, high bulk resources that cannot be efficiently transported to the residential base camp.

Not all collectors will have stations or caches within their settlement organization. The presence of these site types depends upon the predictability, abundance, and distribution of resources within a particular area.

The above list is focussed on some of the possible site types related to resource exploitation and does not describe all possible types of sites utilized by hunter/gatherers (e.g., ceremonial centers). The site types listed above, however, provide a useful heuristic device for examining the archaeological record.

Archaeological Correlates

In general, site types can be identified by the kinds of activities occurring there. Only residential base camps and field camps cannot be distinguished by gross differences in activity types. However, residential bases have a wider range of maintenance, processing, and manufacturing activities than field camps because more resources are exploited at bases.

Given the goal of determining foraging and collecting strategies, how does one identify the characteristic sites? How does one distinguish between a residential base camp, a field camp, and a location? Site types are usually recognized archaeologically by the abundance and diversity of archaeological materials. However, both abundance and diversity can be profoundly affected by sampling strategies and post-depositional processes.

Abundance (the number of artifacts) or density (number per unit area) are used to estimate group size or duration of occupation. Abundant remains or dense midden concentrations are common measures for identifying base camps or villages from surface surveys (cf. Spanne 1974), while small, lithic scatters are frequently classified as specialized sites. Abundance can be affected not only by group size and length of occupation, but also by reoccupation of the site by a later group. Sequential use of an area by a small group may produce numerous remains similar to a single occupation by a large group.

Diversity is the most common measure used for determining site function. The primary distinction between residential base camps and all other site types is based on the number of activities that takes place at the base camp. The wide range of activities is translated into a diverse archaeological assemblage. Field camps, stations, and locations are more specialized and produce a more limited array of artifacts. In fact, the usual assumption is that

residential base camps, field camps, and locations are decreasingly diverse in their assemblages. Diversity can be affected by sample size (Kintigh 1989), reoccupation, length of occupation, type of resources exploited, and use-life of tools (Thomas 1989).

Diversity is a measure of two aspects of variability – the number of categories represented (richness) and the uniformity of the distribution of relative abundance (evenness) (Kintigh 1989). Both of these aspects are important for defining site types. For example, field camps are expected to be more specialized and should be dominated by a limited number of categories. Sample size has a direct bearing on diversity because small samples, by their nature, restrict the number of categories (i.e., a sample of five cannot have more than five categories regardless of the diversity of the population). If the diversity of a number of assemblages vary directly with the sample sizes, then the diversity measure is suspect. The impact of small sample sizes and diversity measures is acute when classifying sites. As Thomas (1989:90) notes, "Dig all of a large site, and you might get a base camp; dig half of the same site, and you've got a field camp; take a surface collection, and it will look like a location."

Site structure complexity can be used to examine whether the site was occupied once by a large group or several times by a small group. Recent ethnoarchaeological investigations allow certain expectations about site patterning to be made for each of these occurrences (Kelly 1988; O'Connell 1987). Investigations of site structure can also be used to examine post-depositional processes as well as changes in group size, mobility, and long-term regional land use. Different organizational and mobility strategies result in different patterns of reoccupation depending upon the structure of the environment. By examining site reoccupation within the study area, we also can look at changes in mobility strategies over time and potential effects of population increase (Binford 1980, 1983; Graham and Roberts 1986; Kelly 1988).

3.2 RESEARCH QUESTIONS

Settlement Organization

Many recent studies of prehistoric settlement and subsistence in California have focused on documenting and explaining the development of complex Native American cultures in coastal areas. For the Camp Pendleton area, early Spanish accounts and ethnographic sources suggest ethnohistoric and historic occupation by the Luiseño and Juaneño was characterized by relatively high population densities and occupation of permanent villages, each of which owned and defended a bounded territory with specific hunting, collecting, and fishing areas. Distant resources may have been procured by special task groups, but seasonal dispersal into small family groups may have been practiced at some times and places. Although it is generally recognized that such a complex system arose from a much earlier foraging pattern, the nature and changing dynamics of prehistoric adaptation in the Camp Pendleton area are poorly understood. Even the most basic research questions remain to be addressed at most sites.

- *How was the Red Beach site (SDI-811) incorporated into the overall settlement system?*

According to the settlement models discussed in the last chapter (e.g., Bean and Shipek 1978; Graham 1981; Koerper 1981; Shipek 1977; True and Waugh 1982), the coastal area near SDI-811 could contain permanent villages or seasonal camps established by inland groups. Floral and faunal assemblages from permanent or semi-permanent residential sites should be relatively abundant, diverse, and indicate exploitation of local as well as non-local resources. Seasonality data should indicate year-round occupation. In contrast, subsistence remains from seasonal camps should be relatively less abundant, less diverse, and indicate a focus on local resources, particularly those that are either available or most abundant during specific seasons.

If the site, SDI-811, was part of a forager's settlement system, it may have been utilized as a residential base camp or a location. If it had been incorporated into a collector' settlement system, then it could have acted as a field camp, a station, or a cache area. It must be remembered, however, that the nature of the site occupation may have changed over time. For example, perhaps the site was originally occupied by a group of foragers collecting shellfish during the fall. Later, the site may have become part of a permanent, year-round occupation of the Las Flores Creek area.

- *How can the Red Beach site be defined in terms of site structure complexity and use of space?*

Site structure refers to the horizontal and vertical distribution of cultural and non-cultural material in the archaeological record. Sites with more complex spatial structures, that is, with more numerous activity areas, particularly secondary refuse areas, are usually considered more permanent than those with simple spatial structures. An activity area is a physical space where one or more identifiable activities were performed. Activity areas consist of an artifact cluster (e.g., a mano and metate), a single feature (e.g., a hearth), or a cluster of features and artifacts. Artifact clusters may be caused by non-cultural as well as cultural processes, so procedures were employed to detect post-depositional disturbance at the site.

Organization of space appears to be directly related to the anticipated length of occupation (Kelly 1992). Longer term sites are usually highly organized in the use of space. The space inside activity areas may be kept "clean." People will sweep the floors and remove litter from living areas (Binford 1983). Midden areas and "messy" activities are placed away from sleeping, cooking, and socializing areas. "Messy" areas are those that either create potentially dangerous debris (e.g., lithic processing, poison dart making) or smelly and otherwise unpleasant jobs (e.g., hide processing, fish drying). In temporary camps, there should not be a clear differentiation between domestic space, middens, and other activity areas. Ethnographic evidence suggests that activity areas will be placed haphazardly because people will not expend the effort to organize and keep clean short-term camp sites in the way they do longer-term camps.

Activity areas are generally larger than individual test units, so broad-scale block excavations are employed to identify activity areas. Initially, the site was investigated with individual test units and stratigraphic trenches. These excavations were used as "windows"

into the structure of the site. High-density zones and/or potential features identified during these investigations were selected for block excavations if they appeared to be cultural in nature.

- *How can the site be defined in terms of food processing activities?*

Food processing is a basic domestic activity characteristically conducted at residential sites and field camps. Food processing may also occur at specialized or limited-use sites that were occupied solely for the procurement of a single food resource (e.g., acorns, seeds). The diversity of processing activities, however, should be more limited at the short-term specialized sites than at longer term camps.

Information on food processing was derived primarily from faunal material, which included burnt bone and shell remains. Paleobotanical specimens (burned seeds, etc.) also provided evidence of food processing. Inorganic materials related to food processing include ground stone, mass quantities of fire-affected rock, and various lithic tool types that may have been used for butchery or other food processing activities. Utilized cobbles and ground stone processing implements were assigned functional interpretations based upon morphological shape and macroscopic evidence of use (e.g., heat fractures and discoloration, grinding facets, pecking depressions, and striae).

- *How does the Red Beach site vary in terms of density and diversity of cultural material?*

Density of artifacts, debris, ecofacts, and features at a site relative to other sites can be used as a crude measure of the permanence or duration of occupation. Sites with higher densities are usually considered to have been more permanent than sites with very few items. They can also represent site reoccupation.

In addition, the diversity of artifact types, animal and plant species, and features provides information on site function. Greater diversity often correlates with a greater number of different on-site activities. It may also indicate longer duration of site occupation or reoccupation.

Counts and/or weights per cubic meter were calculated for the most abundant artifact and faunal classes, particularly debitage, bone, and shellfish remains. Density counts and weights were constructed for different areas of the site in order to compare basic site structure and the possibility of reoccupation. Diversity was calculated in terms of the abundance and sheer numbers of different types of artifacts, faunal species, and features present. These density and diversity factors were then compared to other sites from Camp Pendleton in order to incorporate a broader perspective of changes in settlement structure across a regional area and through time.

- *What functional tool types are represented at the Red Beach site, and what do they indicate about the nature of on-site activities?*

Experiments have demonstrated that flaked stone tool function is most accurately determined through use-wear analysis of whole tools and tool fragments using high-power microscopic analysis (HPMA) (Bamforth et al. 1990). The lithic assemblage from SDI-811

was primarily composed of coarse-grained quartz, volcanics, and quartzite, and these materials are not conducive to HPMA because they do not form diagnostic polishes similar to those found on utilized tools made of chert (personal communication, C. Woodman 1997). Sussman's (1985) preliminary research suggested that HPMA may be useful in analyzing utilized crystalline quartz, but most of the quartz found at SDI-811 was vein quartz that lacks the large crystal planes typical of the pieces used in Sussman's experiments. Given that no reliable microscopic use-wear analysis techniques were applicable to this assemblage, identification of tool function was based on overall tool morphology and macroscopic inspection of edge damage.

- *How does the SDI-811 assemblage vary in terms of the amount of flaked stone tool manufacturing, the stages of tool manufacture, types of tools manufactured, and the degree and pattern of artifact curation?*

These questions focus on data that can be used to identify the relative duration of occupation and the different types of activities associated with a site. For example, briefly occupied, task-specific sites should have little evidence of tool manufacturing, and what little evidence there is should indicate that manufacturing focused on the production of low-energy tools (e.g., utilized flakes) which were expediently produced for the task at hand and discarded immediately after task completion. In contrast, more permanently occupied sites will contain abundant evidence of manufacturing, which will be identified by relatively high flake densities and flakes indicative of a variety of manufacturing stages. This is in keeping with the expectation that the range of activities conducted in a permanently occupied site will be more diverse than the range of activities undertaken in a briefly occupied, task-specific site (Binford 1980). A wider range of tools and, concomitantly, a wider range of manufacturing techniques, should be present in long duration sites.

If there was a temporal shift from a more mobile foraging pattern to a more sedentary collecting pattern, then earlier components should contain higher frequencies of curated tools. Higher rates of curation are largely a response to raw material scarcity, which can be caused by frequent residential moves in an area with highly localized occurrences of knappable material (cf. Bamforth 1988). Relatively high frequencies of expedient flaked stone artifacts, on the other hand, are often associated with areas in which the quality of the available lithic materials is low (i.e., coarse-grained and not suited to the manufacture of finely worked pieces). This means that one cannot reconstruct prehistoric mobility patterns using patterns of artifact curation without considering the nature of the "lithic landscape" (Andrefksy 1994a; Blanton 1984).

Relevant data are technological in nature. They were obtained from worked lithics (i.e., discarded tools, tool fragments, unfinished tools, and cores) and debitage. To identify what techniques of manufacture were used at the site, flaked stone was first classified by material type. The debitage assemblage was then quantified in terms of three attributes (condition, platform type, and width), which were used to determine the types of manufacturing techniques used at the Red Beach Site for each material type. Debitage derive from objective pieces that change form as they are refined, and the resultant debitage changes in form from one stage of the production process to the next. This means that it is possible to assess the stage of production or the degree to which objective pieces were refined at the Red Beach Site by analyzing the debitage. To assess the degree of refinement, each flake was

characterized with regard to the amount of dorsal cortex and the density of dorsal flake scars.

- *How can the Red Beach site be defined in terms of seasonality?*

Seasonality data provide important information on duration of occupation and can help establish a site's role in the regional settlement system. For example, longer-term sites should show evidence of occupation during more than one season. Site seasonality, however, is one of the most difficult aspects of a site to reconstruct. The best indicators come from the faunal, shell, and botanical assemblages. This entails the identification of species that are either physically present in the area during part of the year (i.e., migratory animals) or species that are only edible during certain seasons (i.e., many edible plants). Fish otoliths (ear-bones) can be evaluated for season of death. In the case of SDI-811, the presence of migratory fish and seasonal plant resources provide a baseline for site seasonality, while oxygen and carbon isotopic analyses of *Donax gouldii* remains offer new insight about this critical issue.

Subsistence Orientation

Reconstructing subsistence practices at a site is a necessary precursor to describing and explaining mobility strategies and settlement organization. Recent work at three nearby sites (SDI-10726, -10,728, and -812/H) indicates significant variability in resource use and habitat exploitation (Byrd et al. 1996, 1997; Cagle et al. 1996b), but further excavations and analyses are needed before subsistence patterns can be reliably identified and described in terms of temporal, seasonal, or logistical factors. The presence of shell, bone, and to a lesser degree, charcoal in different cultural strata in both the southern and northern areas indicates SDI-811 can address a wide variety of research questions regarding resource use, habitat exploitation, and seasonality.

- *What habitats occur in the Las Flores Creek (Camp Pendleton) area, with what plant and animal species are they associated, and how do these resources differ in terms of their exploitation potential?*

Mobility strategies are determined by the distribution of critical resources. The first step toward understanding the settlement organization was to identify broad environmental zones and the spatial distribution of key species within them. Environments were partitioned into habitat types based upon soil, vegetation, topography, and hydrology. People living at the site would have had direct access to coastal sage scrub, grassland, chaparral, oak savanna, and limited riparian zones. The animal and plant communities would have offered a diverse range of subsistence resources. Chapter 2 provides a discussion of the project's environmental setting as well as information about resources that were important to the ethnohistoric Luiseño.

- *What is the ethnohistoric evidence for resource use in the project area and adjacent locales; how were these resources procured and used?*

The identification of site types depends upon establishing clear links between theoretical expectations and archaeological correlates of the behavior that produced the sites. These

links can be formed by developing models of ethnohistoric resource use and by identifying the most likely archaeological remains that will result. Specifically, the ethnohistoric record can provide information on group size and composition, structural remains, processing techniques, and tool use. How resources are exploited, either by pursuit or encounter methods, can be used to construct models of settlement organization and mobility for the habitats. A brief description of the ethnohistoric and historic occupation of the region is provided in Chapter 2.

- *What is the archaeological evidence for resource use in the project area and adjacent locales?*

Floral and faunal data from well described, modern excavations provide the best data on subsistence resources and can be used to determine the key species in an area. However, data of this quality are extremely limited in extent. Our effort to address this question focused on comparing SDI-811 to other sites in the Camp Pendleton region, especially those located within the Las Flores Creek area.

Chronology and Dating

The dearth of radiocarbon dates from Camp Pendleton sites severely hampers attempts to describe and explain prehistoric and ethnohistoric adaptations in the region. The relatively few radiocarbon dates that have been collected from Camp Pendleton sites are not sufficient to establish fine-grained temporal controls. As a result, there is no local chronology, and the occupational history of the area is known only in the most general terms (e.g., Archaic, Late Prehistoric).

- *What chronological and cultural periods are represented at the site?*

SDI-811 has excellent potential to help establish a local chronology. It contains a variety of surficial and buried cultural deposits, and most contain the bean clam (*Donax*) or other types of marine shell in sufficient quantities to obtain suites of radiocarbon dates with small margins of error. The large surface area of the site and the presence of buried deposits indicate that the site may have been occupied during a wide variety of time periods. The site also contains cultural deposits from a buried "A" horizon soil that date significantly older than the upper deposits.

Trade and Exchange

The presence of a major spring made Las Flores attractive to settlers and travelers alike. Are artifacts of trade or exchange present at SDI-811? If so, what are the sources of the materials? Within the region, do they indicate exchange between coastal and interior groups? Is there evidence the site's inhabitants participated in the Channel Island interaction sphere? Is there evidence of trade or exchange with groups outside the region? The presence of lithic materials and pottery indicates the site has the potential to address such questions, although the limited comparative data available from other sites on Camp Pendleton hampers interpretations.

Native American Heritage Values

SDI-811 has the potential to be of heritage value to Native Americans. Archaeological data indicate the Red Beach area contains Late Prehistoric residential sites, which could be ancestral to the Luiseño/Juaneño. Native Americans will be given the opportunity to review this report and comment on the heritage value of the site.

4 FIELD AND LABORATORY METHODS

Karen A. Rasmussen

4.1 INTRODUCTION

The field and laboratory methods for the data recovery project at SDI-811 were designed to (1) mitigate the potential impacts to the surface and subsurface archaeological deposits at SDI-811 and (2) recover a representative sample of spatial and temporal variability inherent in the site in order to address the various research questions outlined in the previous chapter. Archaeological fieldwork was conducted between April 28 and May 23, 1997.

4.2 FIELD INVESTIGATIONS AT CA-SDI-811

The field investigations were carried out within a multi-stage research framework that included both probabilistic and nonprobabilistic (judgmental) sampling elements. Before proceeding with this discussion, however, it is important to draw a distinction between the *target populations* about which inferences are sought and the *sampled populations* from which such inferences must actually be developed. This division has both important theoretical and practical implications. As defined here, target populations are synonymous with the entirety of the site subject to mitigative investigations. That is, a target population is a whole site, including its attendant formal, spatial, and temporal variability. A sampled population, on the other hand, is that portion of the site actually available for investigation.

Although in many instances target and sampled populations are equivalent, this is not the case with the SDI-811 data recovery program. Subsurface excavation was confined to the Area of Potential Effect (APE) (see Figure 1-2) and, consequently, the sampled population was restricted to a relatively narrow corridor crossing the site.

At SDI-811, the APE corridor transects relatively intact cultural deposits. Consequently, site investigations focused on acquisition of data useful for two distinct types of analytic goals: (1) estimation of the numbers and kinds of cultural remains occurring within the APE; and (2) identification and interpretation of horizontal and vertical patterning of those remains.

Past experience and abundant experimental evidence indicate that quite different types of sampling design schema provide the most efficient and effective means of acquiring necessary and sufficient data to address the two research goals identified above (cf., Jermann 1981; Nance 1983). Briefly stated, use of probabilistic sampling designs is necessary to develop unbiased estimates of descriptive population parameters (e.g., numbers and densities of various artifact classes occurring within the APE), and purposive (judgmental)

designs provide the most efficient means of characterizing intra-site spatial patterning. Given that knowledge of both site content and site activity patterning are crucial to resolution of the research questions developed in the previous chapter, both types of sampling strategies were employed at SDI-811 as part of the data recovery program.

Vegetation Removal and Surface Collection

The vegetation on the surface of the site rose up to eight feet in height and was dense enough to make clearing by hand unfeasible. A small bulldozer was brought in to flatten the ground cover so that the crew and vehicles could access the APE.

The surface of the site had been previously disturbed by agricultural practices, livestock ranching, various construction and earth moving activities, and military maneuvers. Due to the obvious surface disturbance, cultural material was not systematically collected along the APE. Instead, the surface collection concentrated on the recovery of formal artifact types, temporally diagnostic artifacts, and cultural material that may be useful in sourcing studies (e.g., obsidian), all of which could potentially provide information on the range of activities performed at the site, the manufacturing technology employed, and the relative age of the site. The APE was surveyed (see Figure 1-3), but only those artifact types meeting the above criteria were pin-flagged, mapped, and collected. The collected artifacts were then placed in bags labeled with the appropriate provenience information. The surface area surveyed was approximately 106,070 ft^2 (9,854 m^2), and a total of fourteen artifacts were collected through this process, including hammerstones, retouched flakes, a pot sherd, and a basalt bowl fragment (see Appendix A).

Excavation Procedures

Twenty-four units, totaling 20.5 m^3 in excavation volume, and thirteen backhoe trenches, totaling 151.5 m^3 in volume, were excavated during the data recovery project (Figure 4-1). The units measured 1 x 1 m in dimension, and the backhoe trenches measured approximately 1 x 5 m. The upper 40 cm of the units, a plowzone, were excavated in two 20 cm levels. Excavations then continued in 10 cm arbitrary levels. The backhoe trenches were excavated in 20 cm arbitrary levels.

Nine excavation units (Units 100-108) were placed in regular, systematic intervals along the proposed sewer line in the area of the site with high-density cultural deposits. Another three units (Units 109-111) were placed along the proposed sewer line in areas previously designated as low-to-moderate density deposits in the northern section of the site. The backhoe trenches (T 100-112) were placed at regular, systematic intervals along the proposed sewer line in areas thought to have little cultural material.

Based on the results of the backhoe trenches and the first twelve excavation units, three more discrete units were judgmentally added in areas previously untested (Units 112, 121, and 123). Unit 112 was placed near the wetland area in order to gauge the horizontal extent of the cultural deposits near this zone. The wetland area was not tested due to the high water table. Unit 121 was placed between Units 104 and 107 to test whether the possible features noted in the latter two units extended into the area between them. Unit 123 was

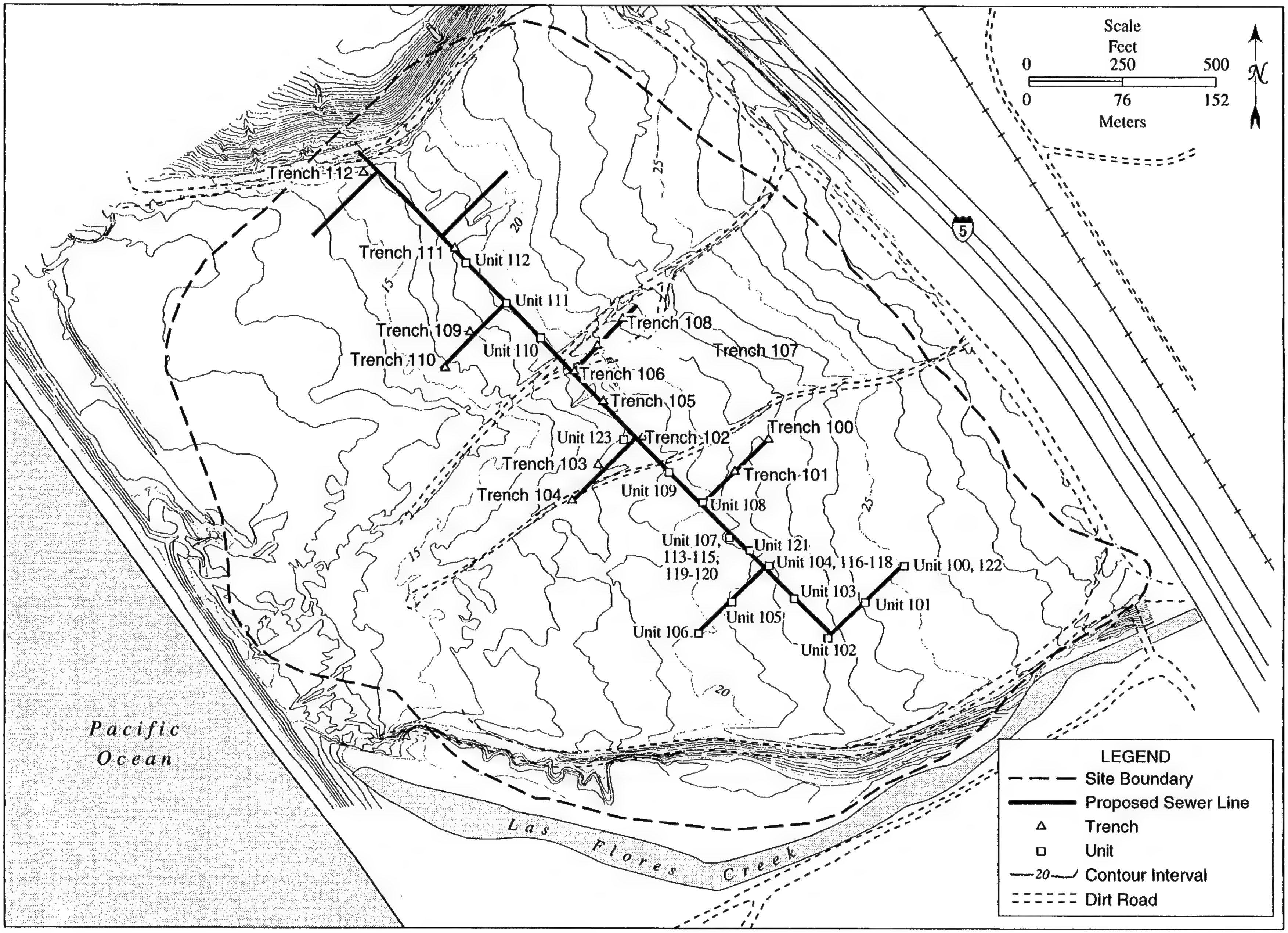


Figure 4-1. Location of the Excavation Units and Backhoe Trenches at CA-SDI-811

placed near Trench 102, which tested positive for cultural material, to gather a sample of material from that area of the site.

Finally, excavations were judgmentally expanded around three of the original twelve units (Units 100, 104, and 107) because of the density of the deposits and the possibility of locating cultural features. Unit 100 contained the highest density of shell from the site. A second unit (Unit 122) was placed extending off of the north wall of Unit 100 in order to increase the recovery of faunal material and rare artifacts. Units 104 and 107 contained dense concentrations of fire-affected rock. Unit 104 was expanded into a 2 x 2 m area with the additions of Units 116, 117, and 118. Unit 107 was expanded into a 6 m^2 excavation area with the additions of Units 113, 114, 115, 119, and 120 (Figures 4-2 and 4-3). The results of the systematic and nonsystematic excavation strategies will be discussed in next chapter.

Hand-excavations were conducted primarily with shovels, although breaker-bars and hand picks were employed in some of the more compact areas. Trowels and other more precise digging tools were used in the fire-affected rock areas of the site. The units were excavated by teams of 2 to 3 archaeologists. Two crew chiefs monitored the progress of the field crew and verified that excavation and documentation procedures were consistent throughout the entire project.

The units ranged from 30 cm to 150 cm in depth. The excavation material was dry-screened in the field and size-sorted into 1/4" and 1/8" categories (on-site water-screening was not feasible during the excavations). All cultural material and residue from the 1/4" mesh was bagged by provenience and taken back to the laboratory for water-screening. Due to the difficulty of dry-screening through 1/8" mesh, the excavators collected the observable cultural material from the 1/8" screens and then discarded the residue. Systematic samples of the 1/8" and 1/16" material were collected through the column samples. In the case of fire-affected rock, only a sample was retained for further analysis when found in high quantities.

An auger probe was placed in the floor of one unit from each excavation area in order to investigate the possibility of buried deposits. The auger material was screened, and the observable cultural material was collected and recorded. Augers were excavated to the existing water table or until APE depth (7 feet), whichever was reached first.

A 25 x 25 cm column sample was taken from the side-wall of one unit of each excavation area. The column samples provided samples of material for flotation processing or fine-mesh waterscreening. Nine samples, coinciding with either well-dated midden deposits or the fire-affected rock concentrations, were submitted to the UCLA Paleoethnobotany Laboratory for flotation processing and macrobotanical analysis. The rest of the material was water-screened with 1/16" mesh. The column samples were excavated using the same arbitrary 10-20 cm intervals utilized in the excavation of the unit. This method allowed for the recovery of a manageable sample of the small faunal, botanical, and other cultural material that would normally be lost with the use of a larger screen size. The material was also directly comparable to the larger samples from the corresponding units because of the identical excavation intervals.

The backhoe trenches (Figure 4-4), designated as T-#, were excavated in approximately 20 cm levels, and had depths ranged from 1.5 to 3.8 meters below the surface. The excavation

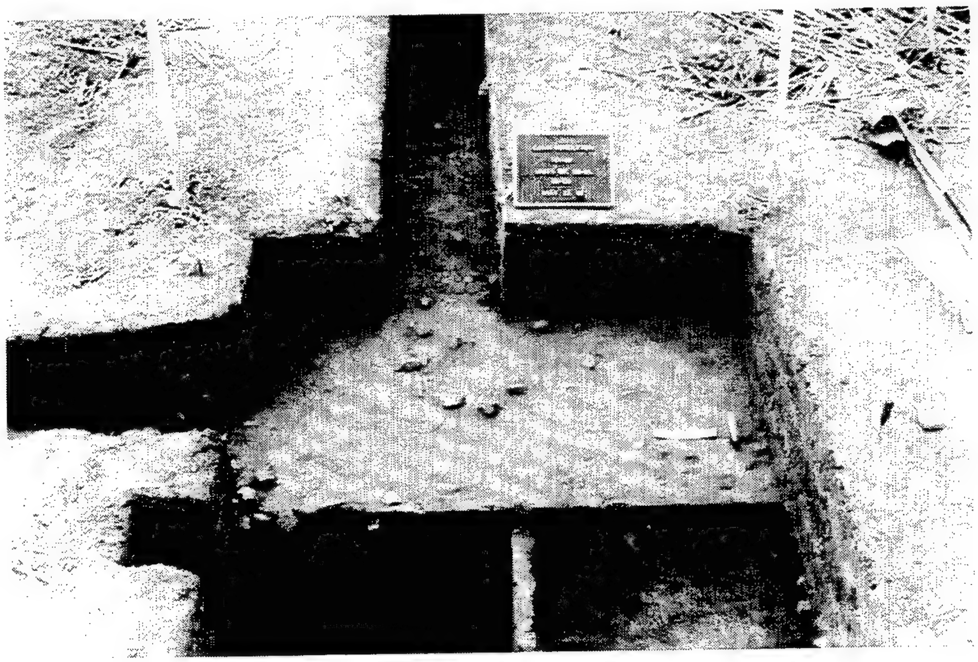


Figure 4-2. Horizontal Excavation Block of a Fire Affected Rock Area (FAR I)

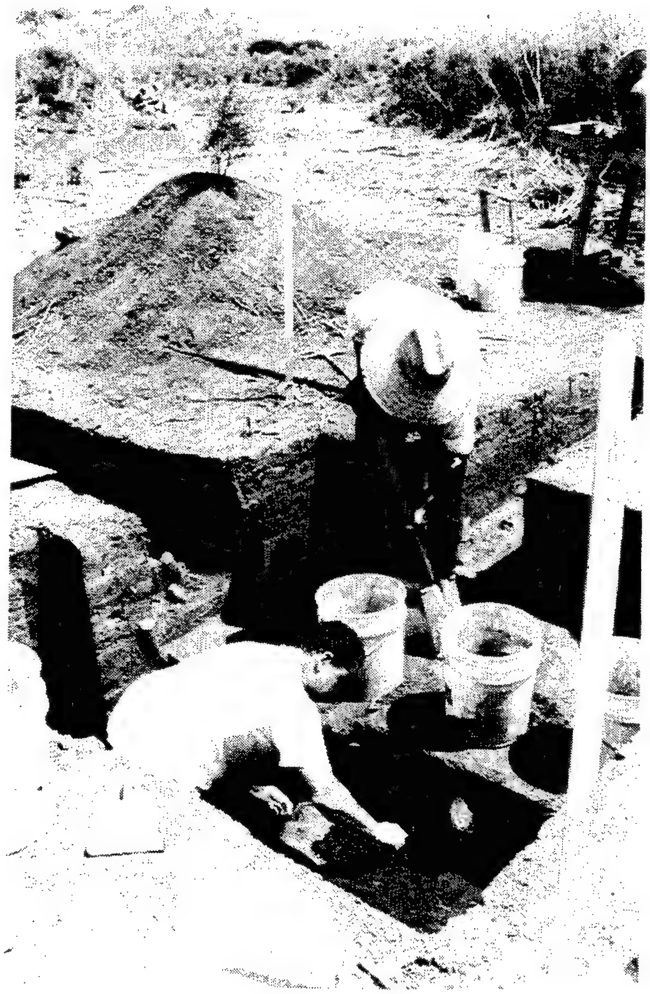


Figure 4-3. Excavations within a Fire Affected Rock Area (FAR I)

Figure 4-4. Photograph of a Typical Backhoe Trench *(note the high water table)*

depth was determined primarily by the level of the water table. Detailed descriptions of the trench profiles are provided in Appendix E. Trenches were used instead of hand-excavated units in areas thought to contain little cultural material, and only two trenches (T-102 and T-109) yielded artifacts. One retouched flake was located in the 20-40 cm level of T-102. A few fragments of shell and fire-affected rock were seen in the first two levels of T-109. Field crew paid special attention to the presence or absence of cultural material in the deeper deposits exposed in the trench profiles.

Stratigraphic Profiles

Upon completion of a unit or trench, the field crew and the project geomorphologist documented the exposed stratigraphy. This documentation consisted of identifying stratigraphic divisions within the profile and preparing a large scale drawing of one or more walls of the unit. All evidence of disturbance (e.g., plow scars, krotovina) was included in the profile drawing.

All strata were described according to their color, consistency, and texture. Standard soil and sedimentological terminology and definitions were used in the descriptions. The descriptions included information on the relationship of the particular stratum to the distribution of cultural remains within the unit.

Geomorphological Studies

The geomorphologic investigation by Mitchel Bornyasz (Figure 4-5) (Earth Consultants International, Inc.) established the geoarchaeological context of the cultural deposits and associated artifacts. Specific issues investigated include (1) the types of depositional environments represented by the natural sediments present, (2) the stratigraphic relationships between the sediments and cultural deposits, and (3) possible evidence for post-depositional disturbance of cultural materials within the site.

Geologic deposits and the soils developed within them were exposed in cross section within the excavated test units and backhoe trenches. The deposits and soil profiles exposed were examined and described following recognized geologic and pedologic guidelines and nomenclature (see Appendix E for more details).

The characteristics of geologic deposits generally reflect the depositional environment of the sediments that compose them. Therefore, the sedimentologic and stratigraphic characteristics of the deposits were evaluated and used to interpret their primary depositional environment. Deposits displaying soil profile development were described in detail using USDA Soil Survey Staff (1992) guidelines and nomenclature. Soil profile descriptions document the following: profile thickness (where possible), degree of horizonation, color (dry and moist; Munsell color notation), field estimation of texture (<2mm grain size fraction — USDA ternary texture chart, >2mm fraction — percent pebble and cobble gravel present), soil structure, consistence (wet and dry), thickness, abundance and location of clay films, horizon boundaries, pore space morphology and abundance, and secondary carbonate.

Documentation

Documentation included standardized level and unit records, surface collection records, and photographic records as well as the daily notes maintained by the field director supervising the fieldwork. The following describes in more detail the types of documentation used for this project.

- **Surface Collection Form.** Details the provenience, context, and characteristics of artifacts recovered through surface collection.

- **Field Unit Form.** Summarizes information on unit provenience, depth, volume, size, and content. Also includes the rationale for placement and termination of the unit.

- **Field Level Form.** In addition to standard provenience data, presents volumetric, stratigraphic, disturbance, and content information for an excavated level; lists point provenienced artifacts, photographs, and special samples associated with the level; includes a map of the level, if appropriate, showing larger constituents and/or horizontal stratigraphic differences.

- **Field Feature Form.** Provides comprehensive data on the location, shape, size, content, and other characteristics of an excavated feature; summarizes methods used to excavate the feature and lists any special samples collected.

- **Field Photographic Log.** Lists the location and subject of each photograph for a specific roll of film; includes information on type and speed of film used, direction of photograph, date, and name of photographer.

- **Field to Lab Inventory Form.** Provides a daily inventory of the cultural material recovered from the site; used to track material from the field in Oceanside to the laboratory in Santa Barbara.

Although most of these forms were completed by field crew members, a crew chief reviewed the records daily to ensure their completeness, accuracy, and consistency. In addition, the field director scrutinized all forms and documentation. Laboratory personnel then checked the documentation relative to the materials and special samples sent in from the field. This system of multiple reviews ensured that all documentation was rigorously examined and verified.

Photographs, both black-and-white prints and color slides, were used to document the overall site setting, stratigraphic profiles, features, and artifact concentrations. In addition, the field personnel used photographs to document evidence of disturbance and field methods.

4.3 LABORATORY METHODS

All of the cultural material recovered from SDI-811 was brought back to the SAIC office in Santa Barbara for processing and analysis. The types of analyses performed on the material were designed to provide information necessary to address the research questions outlined in the previous chapter.

Figure 4-5. Geomorphological Investigations at the Red Beach Site

Water-Screening

The cultural material and screen residue from the 1/4" mesh recovered from the site excavations as well as the observable cultural material hand-picked from the 1/8" mesh were water-screened at the laboratory through 1/4" or 1/8" mesh, whichever was equivalent to the mesh size used in the recovery of that particular sample. On-site water-screening was not feasible during the excavations. The column sample material that was not sent to the UCLA Paleoethnobotany Laboratory for flotation analysis was water-screened through 1/16" mesh. The 1/16" column sample material was then size-sorted into 1/4", 1/8", and 1/16" residue.

Cataloging

After water-screening, the material was rough sorted by the laboratory crew into one of the following 12 different class types: lithics, groundstone, cobble tools, bone, shell, charcoal, botanical remains, fire-affected rock, ceramics, historic artifacts, miscellaneous, or undifferentiated/unsorted. The lithics were further sorted into biface, core, debitage, flake tool and projectile point categories. They were also separated by basic material type (i.e., chert, quartz, quartzite, volcanics, granitics, metamorphic). The groundstone was also differentiated by basic categories (e.g., mano, metate, mortar, pestle) and material type. Worked bone and shell were separated from the undifferentiated fragments. The historic and modern debris were separated by material type (e.g., glass, metal).

The 1/4" and 1/8" material from the column samples were rough sorted and cataloged. The 1/16" residue was scanned for artifacts and diagnostic faunal elements and then discarded.

A catalog of the entire collection was created in the program *FileMaker Pro*, using a coding system developed for SAIC-derived artifact collections. The catalog includes provenience information, screen size, basic artifact descriptions (including signs of modifications), counts, weights, the initials of the cataloger, the date cataloged, and any additional comments.

Camp Pendleton will curate the collection according to Federal Regulation 36 CFR Part 79 at the San Diego Archaeological Center through the San Diego Repository Corporation, and the collection will remain the property of the Government.

Lithic Analysis

The flaked stone assemblage was first separated into five basic categories: biface, core, debitage, flake tool, and projectile point. The items were then classified by material type. The formal tools and a subset of the debitage assemblage was analyzed by Sean Hess. The results of this analysis can be found in Chapter 6.

Faunal Analysis

The faunal material from the 1/4" mesh of the unit excavations as well as the 1/4" and 1/8" mesh from the column samples was selected for further analysis. The assemblage was first separated into fish and non-fish categories. Dr. Jean Hudson examined the non-fish assemblage, while Karen Rasmussen identified the fish bone. The bone fragments were

identified to the most specific taxonomic level possible. In addition, a record was kept on element type, siding, and signs of modification.

The shell remains recovered from the 1/4" mesh of the unit excavations were separated to the most specific taxonomic level possible by the laboratory crew. All identifications were subsequently checked by Karen Rasmussen. The shell fragments were weighed and a minimum number of individuals (MNI) count was derived for the entire assemblage. The results of the vertebrate and invertebrate analyses can be found in Chapters 7 and 8, respectively.

Finally, a sample of *Donax* shells was submitted to Doug Kennett for isotopic analysis. The results of his study are in Chapter 9.

Botanical Analysis

Nine samples from the column sample material, comprising 67.5 liters of soil, were submitted to the UCLA Paleoethnobotany Laboratory for flotation processing and macrobotanical analysis. Samples were chosen to coincide with well-dated midden deposits and the fire-affected rock scatters. The results of their analysis can be found in Chapter 10.

Radiocarbon Dating

Eight samples were submitted to Beta Analytic, Inc. for radiocarbon dating. The results of the radiocarbon dates are provided in the following chapter.

5 SITE STRUCTURE AND AGE

Karen A. Rasmussen

This chapter describes site stratigraphy, chronology, and the analytic units used in analyzing spatial and temporal variations within the Red Beach site.

5.1 SITE STRATIGRAPHY

Soil Stratigraphy

SDI-811 is situated within the Las Flores Creek floodplain, an alluvial fan that forms a low terrace at the shoreline. The soil stratigraphy appears to be fairly consistent across the entire site area (Figure 5-1). The surface soil consists of a dark, organically rich A horizon, which could often be separated into two distinct layers, A1 and A2. A1, which usually correlated with the top 40 cm of soil, appears to represent a plowzone while the lower A2 soil strata appears to contain more intact deposits. Next, there is usually a transitional AC stratigraphic layer, representing a mixed deposit of the surface A horizon and the underlying C horizon. This mixture is probably due to bioturbation. The C horizon consists of fine-grained fluvial sediments (see Appendix E for more details about the soil stratigraphy).

Signs of a buried A horizon soil, labeled Ab, beneath the C horizon strata was seen in several of the 1997 excavation exposures, including Units 100-103, 109, 115, 116 and Trenches 102, 103, 110. In addition, a buried A horizon was observed during the 1995 test excavations in Trench 1 at 80-165 cm, in Trench 4 at 114-148 cm, and in Trench 6 at 128-137 cm below the surface (Cagle et al. 1995). The Las Flores Creek alluvial fan had a very active depositional history, leaving behind a series of buried deposits (Waters 1996). An approximately 10-m high cut bank adjacent to Las Flores Creek (Figure 5-2) provides an exposure of a sequence of 3 to 4 buried A soil profiles representing a number of potential occupation surfaces at this locality (see Byrd et al. 1996 for more details).

Site Disturbance

Natural and cultural processes affecting the integrity of archaeological sites often are recorded in the soil-geomorphologic record (Wood and Johnson 1978). Cultural disturbances generally include construction-related earth-moving activities, agricultural pursuits, livestock ranching, and off-road vehicle transportation. Natural processes affecting site integrity include erosion and pedoturbation (i.e., soil mixing processes). Pedoturbative

processes within the study area are generally limited to bioturbation (i.e., biologically induced soil mixing).

The surface area of the Las Flores Creek alluvial fan has been subjected to various types of disturbance. Construction-related disturbances or modifications within SDI-811 include (1) those in which deposits have been removed from their original location (i.e., truncation or excavation) and (2) those that have mixed and disturbed the natural profile of the deposits (i.e., furrowing, ripping, and disking). The surface area has been altered by military activities, such as the construction of graded dirt roads, gravel roads, and a small east-west trending levee. In addition, historic airphotos from the 1930s demonstrate that the entire area had been under cultivation (Byrd et al. 1996). Soil mixing in the top 40 cm of the site appears to be the result of plowing and other agricultural activities.

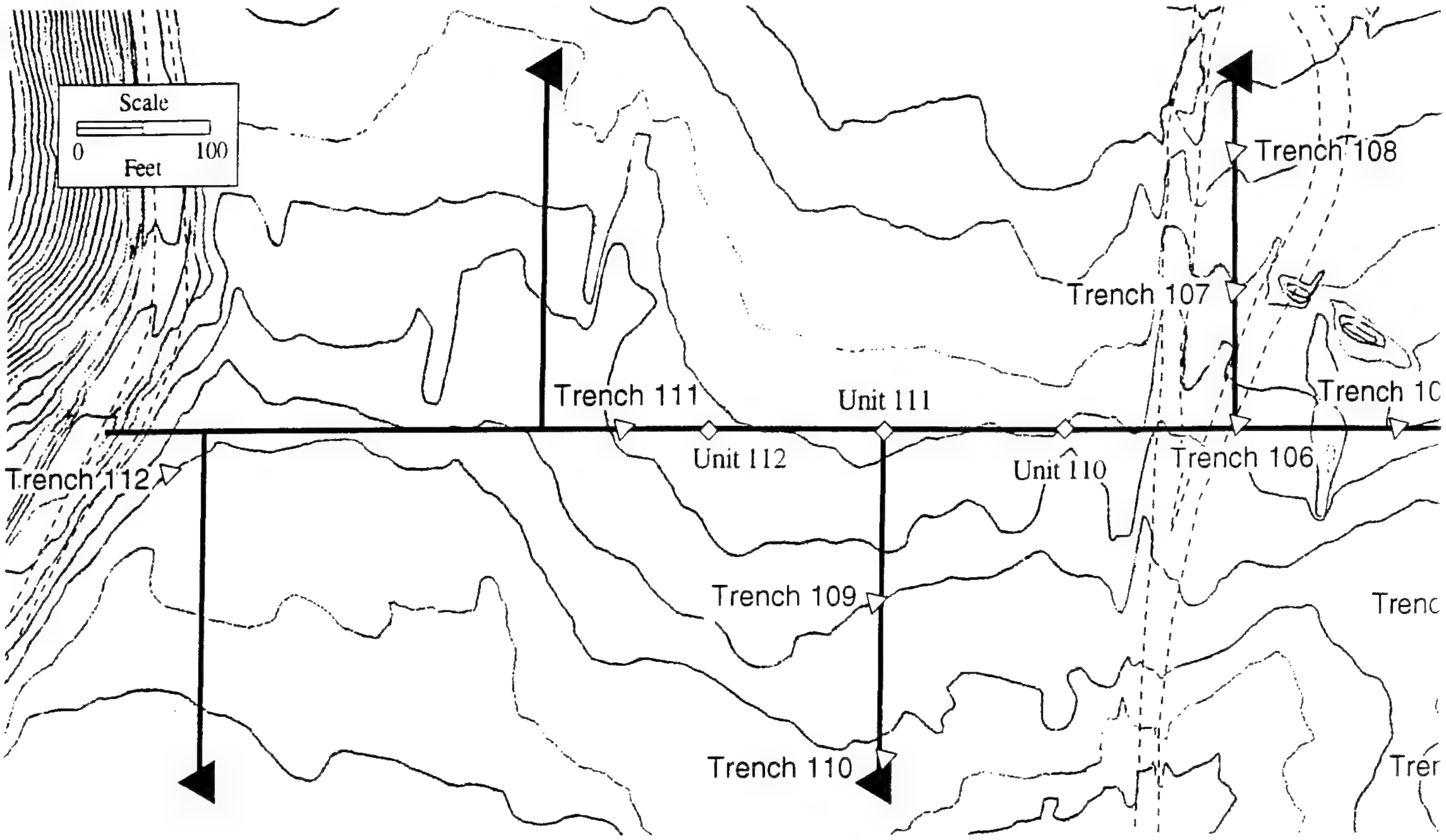
Natural disturbances also occur. Bioturbation (floral and faunal soil mixing) is generally limited to the upper soil horizons (A and upper C horizons) and controlled by the depth of animal burrows and root growth. The majority of surface horizons exposed in each test excavation display evidence of the presence of burrowing insects and roots. Open rodent burrows are present locally and krotovina (filled burrows) are common in the upper portions of profiles. Rodent burrows and root disturbance were seen throughout most of the excavation profiles.

Eleven rusted metal fragments and three very small pieces of glass were recovered during the 1997 excavations. They're highly fragmentary and, in the case of the metal, corroded state made it impossible to determine either their original use or their antiquity. They probably derive from historic agricultural practices or more recent military activities. All of the metal fragments and one of the glass pieces were found in the upper 40 cm of the site, the plowzone. Two glass fragments were recovered from deeper deposits. One piece of glass (Catalog # 1893) was recovered from the column sample in Unit 122 at a depth of 60-70 cm below the surface, and the other glass fragment was found in the column sample of Unit 115 at a depth of 70-80 cm below the surface. Finally, one piece of metal was recovered from the 80-90 cm level of the column sample in Trench 6 during the 1995 test excavations of the northern half of the site (Cagle et al. 1995). Bioturbation probably accounts for the few pieces of glass and metal recovered below the plowzone.

5.2 SITE STRUCTURE

Cultural remains were recovered from within the surface A horizon throughout much of the alluvial fan. ASM's (Byrd et al. 1996) test excavations at the site revealed a continuous surface scatter of material in the southeast portion of the site while SAIC's (Cagle et al. 1995) 1995 testing demonstrated the presence of cultural deposits in the northern half of the site.

Table 5-1 provides raw counts and weights of cultural material and Table 5-2 provides density information regarding the 24 units excavated during the current testing project. This information is displayed graphically in Figure 5-3. The cultural material is composed primarily of flaked stone, animal bone, shellfish, and fire-affected rock. In addition, small amounts of ceramics, groundstone, corroded metal, glass, and botanical remains were recovered from some of the units (see Artifact Catalog in Appendix A). Figure 5-3 contains


Scale
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Trench 108
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Unit 111
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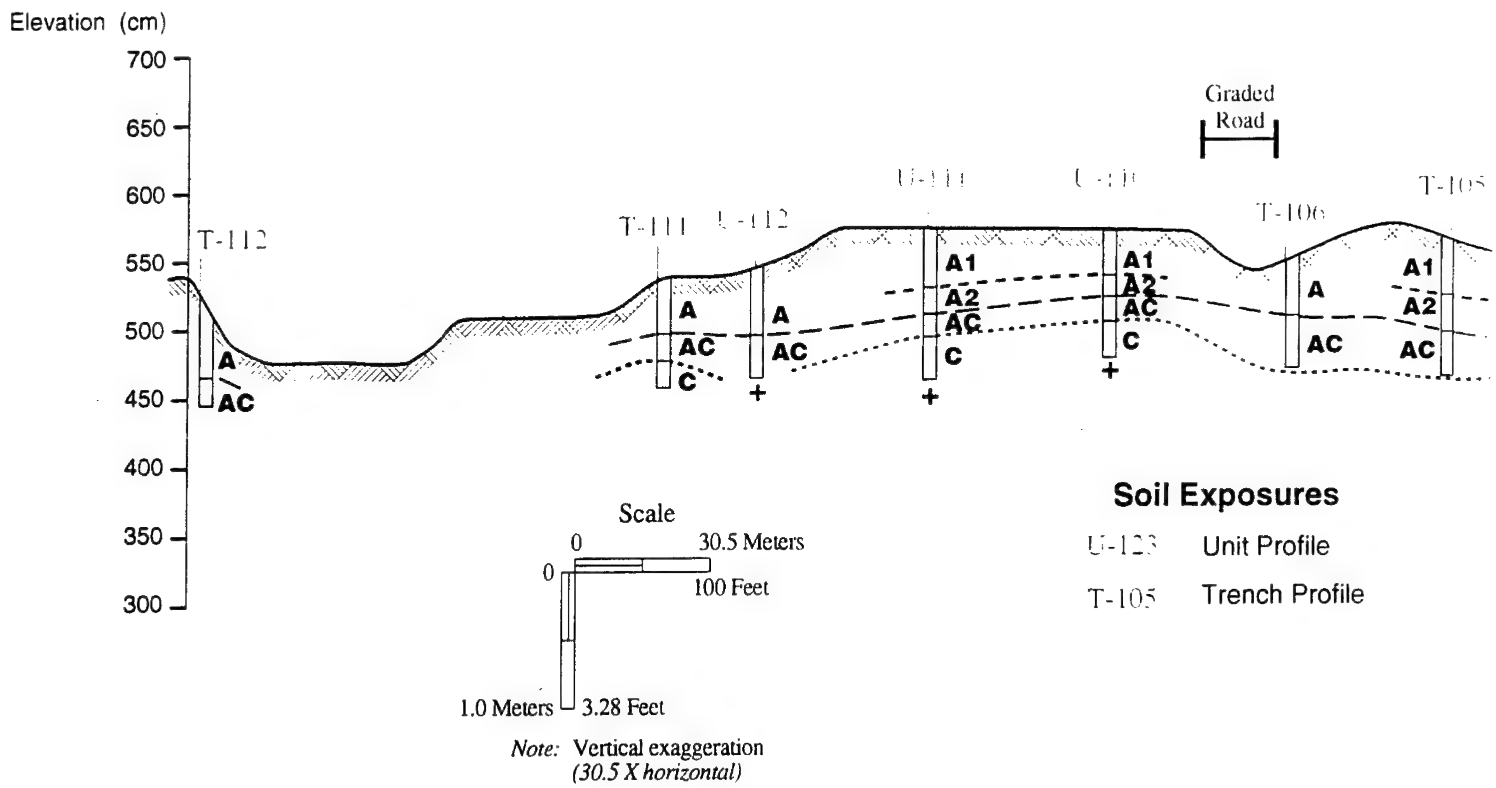
Elevation (cm)
700
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Graded Road
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A
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A2
C
Soil Exposures
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30.5 Meters
100 Feet
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3.28 Feet
Note: Vertical exaggeration (30.5 X horizontal)

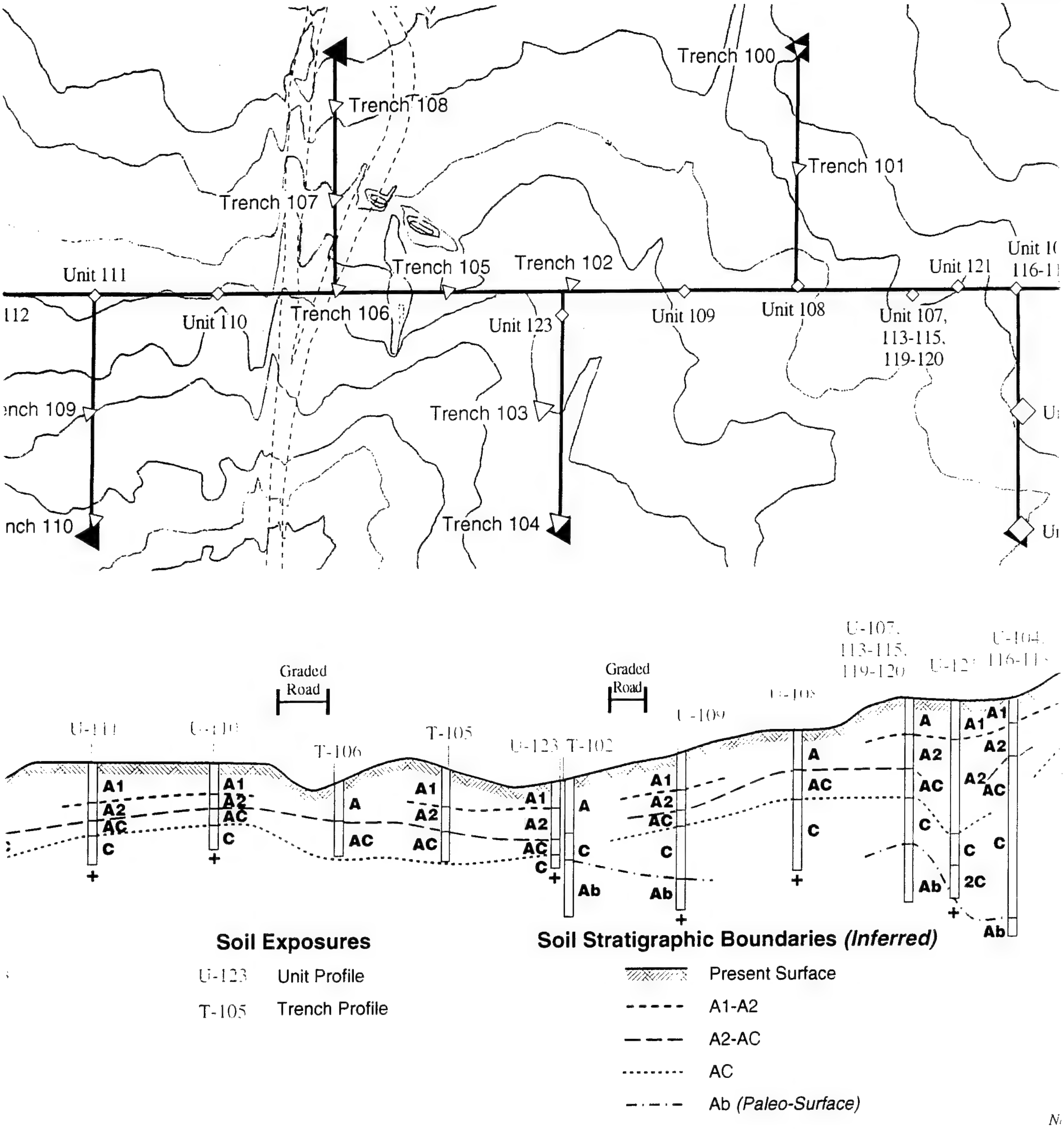


Figure 5-1. Geomorp

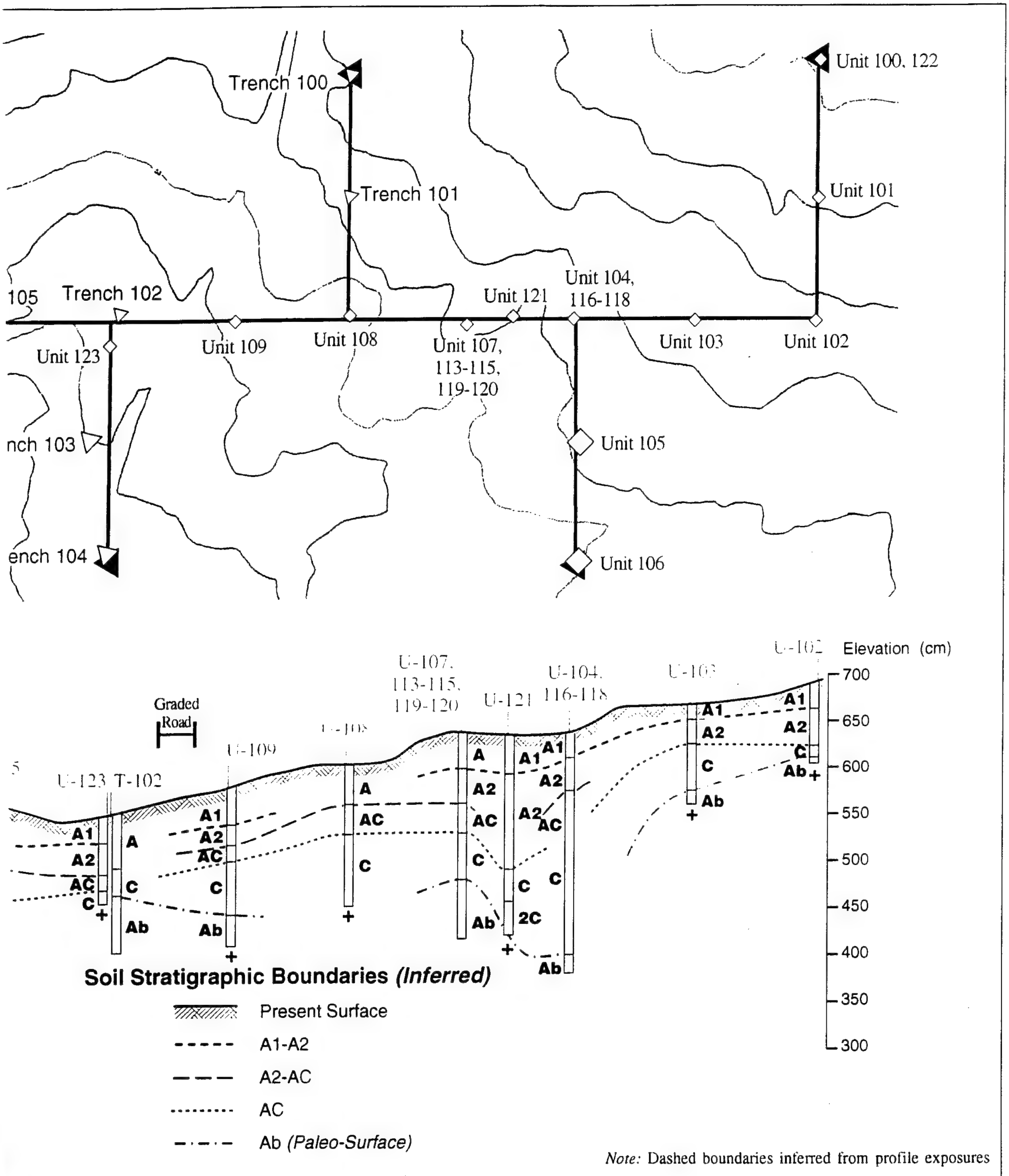


Figure 5-1. Geomorphological Cross-Section of the Red Beach Site

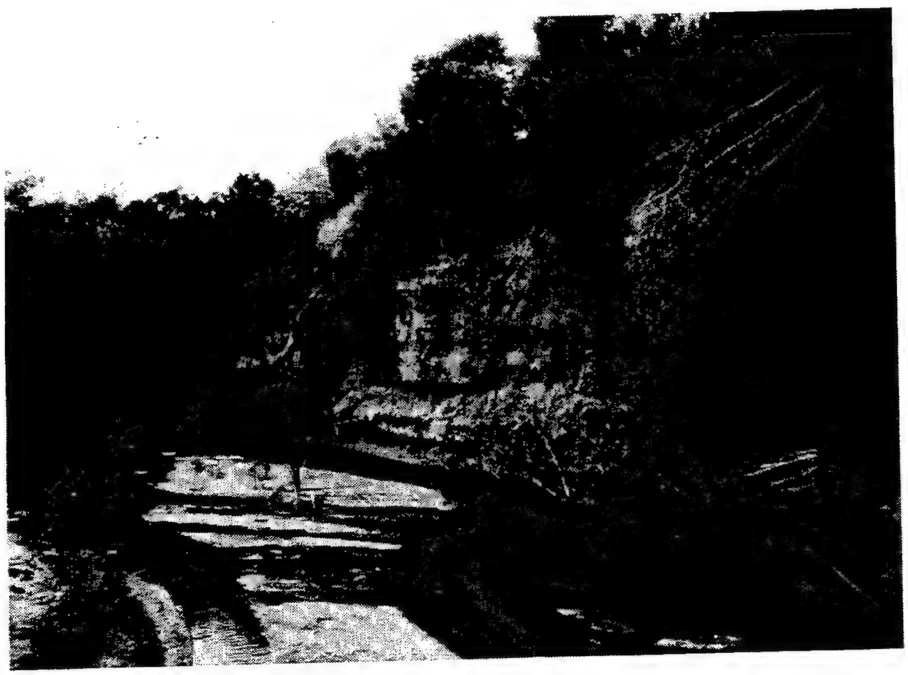


Figure 5-2. Photograph of Las Flores Creek Profile

Table 5-1. Horizontal Distribution of Cultural Material at CA-SDI-811

Unit	*Flaked Stone (ct)*	*Bone (g)*	*Shell (g)*	*FAR (g)*
100	91	24.8	2,184.93	5,160.2
101	24	1.0	42.92	369.4
102	7	4.3	11.73	82.3
103	20	1.5	340.34	366.3
104	99	23.0	71.86	3,154.3
105	21	1.4	11.45	912.2
106	7	0	8.68	277.9
107	205	56.7	6.02	19,438.0
108	125	7.7	6.97	1,580.3
109	258	164.8	82.54	1,838.1
110	59	10.7	100.25	1,177.3
111	19	1.9	5.63	57.1
112	4	0.5	4.91	6.8
113	130	11.1	1.79	9,651.9
114	221	65.7	1.29	9,283.3
115	226	156.7	5.87	21,900.7
116	182	159.6	325.61	41,961.3
117	158	83.7	186.97	28,449.9
118	50	6.1	16.59	5,155.4
119	50	8.8	0	6,387.8
120	69	19.6	4.22	11,658.3
121	263	68.8	337.62	8,665.2
122	70	47.4	1,971.36	5,935.9
123	31	7.6	3.60	513.4

Note: > 1/4" material only

Table 5-2. Density of Cultural Material at CA-SDI-811

Unit	Excavated Volume (m³)	Flaked Stone (ct/m³)	Bone (g/m³)	Shell (g/m³)	FAR (g/m³)
100	1.1	83	23	1,986	4,691
101	0.8	30	1	54	462
102	0.8	9	5	15	103
103	0.7	29	2	486	523
104	0.5	198	46	144	6,309
105	0.7	30	2	16	1,303
106	0.7	10	-	12	397
107	0.7	293	81	9	27,769
108	1.0	125	8	7	1,580
109	1.5	172	110	55	1,225
110	0.7	84	15	143	1,682
111	0.7	27	3	8	82
112	0.3	13	2	16	23
113	0.6	217	19	3	16,087
114	0.9	246	73	1	10,315
115	1.3	174	121	5	16,847
116	1.5	121	106	217	27,974
117	1.1	144	76	170	25,864
118	0.5	100	12	33	10,311
119	0.5	100	18	-	12,776
120	0.5	138	39	8	23,317
121	1.5	175	46	225	5,777
122	1.1	64	43	1792	5,396
123	0.8	39	10	5	642

Note: > 1/4" material only

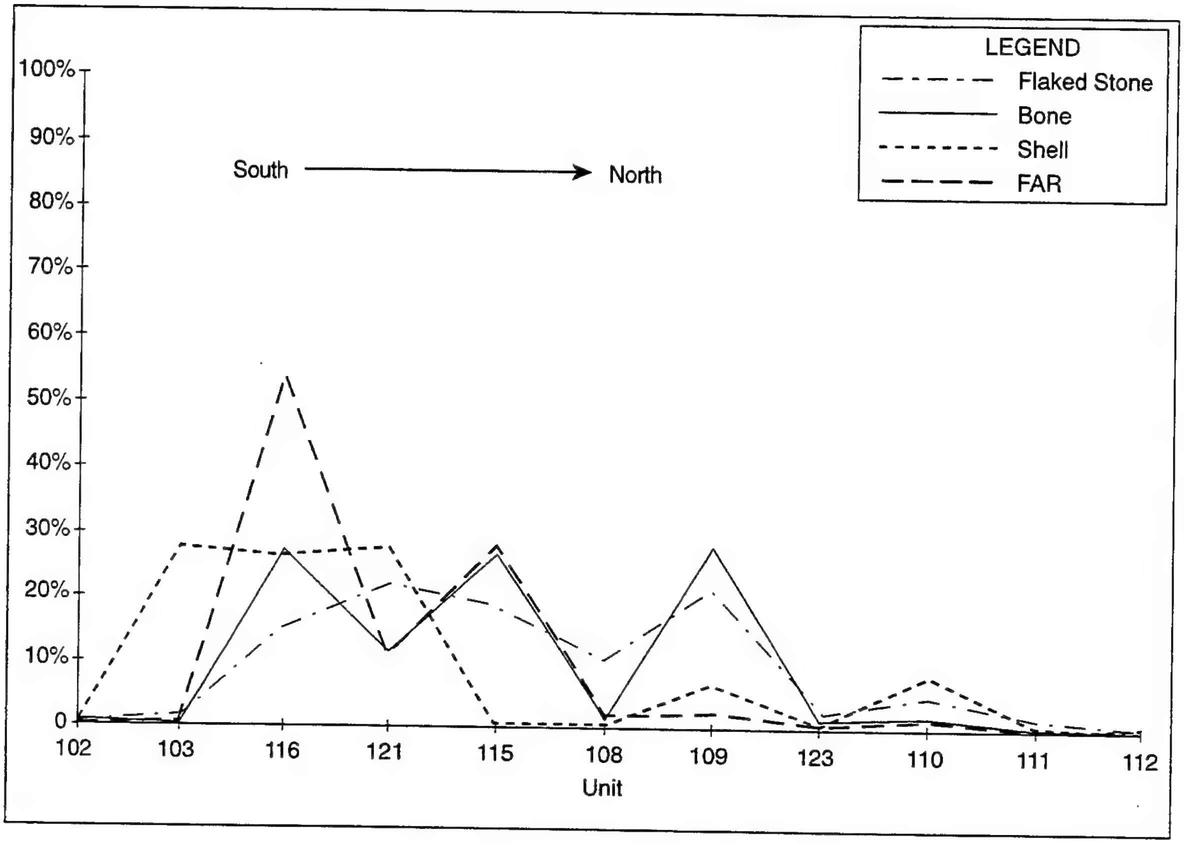


Figure 5-3. Graph of the Artifact Densities running from South to North across the Red Beach Site

information from only those units excavated along the centerline of the proposed pipeline of the APE (i.e., those listed on Figure 5-1). The graph disregards those units along the side arms of the APE, such as Units 105 and 106, in order to provide an overview of the distribution of archaeological material from south to north.

The site displays strong horizontal patterning. The southern portion of the site contains high density deposits, while those in the north demonstrate cultural deposits of only low-to-moderate density. The shellfish and the fire-affected rock display the most distinct spatial patterns. Shellfish is concentrated in the southern portion of the site, almost disappears from the assemblage within one of the block excavation areas (Units 107, 113-115, 119-120), and reappears in moderate levels in the northern portion of the site. The fire-affected rock assemblage is concentrated within the two block excavation areas, which have such high concentrations of burnt rock that the block areas are defined, below, as Fire-Affected Rock Area I (FAR I) and Fire-Affected Rock Area II (FAR II).

Based on stratigraphy and densities of cultural material, the site structure is described below in terms of five distinct areas: two relatively dense midden deposits, two broad scatters of fire-affected rock and other materials, and a cultural deposit within a buried A horizon soil.

This discussion will also highlight the strong vertical patterning of cultural material within SDI-811.

Midden Areas

Scatters of midden appear throughout the site; however, two excavation areas, Unit 100/122 and Unit 109 (see Figure 5-16 below), are unique in that they contained very dense concentrations of shell and animal bone compared to the rest of the site. Despite these general similarities, these two midden deposits yielded very different assemblages and were not contemporaneous.

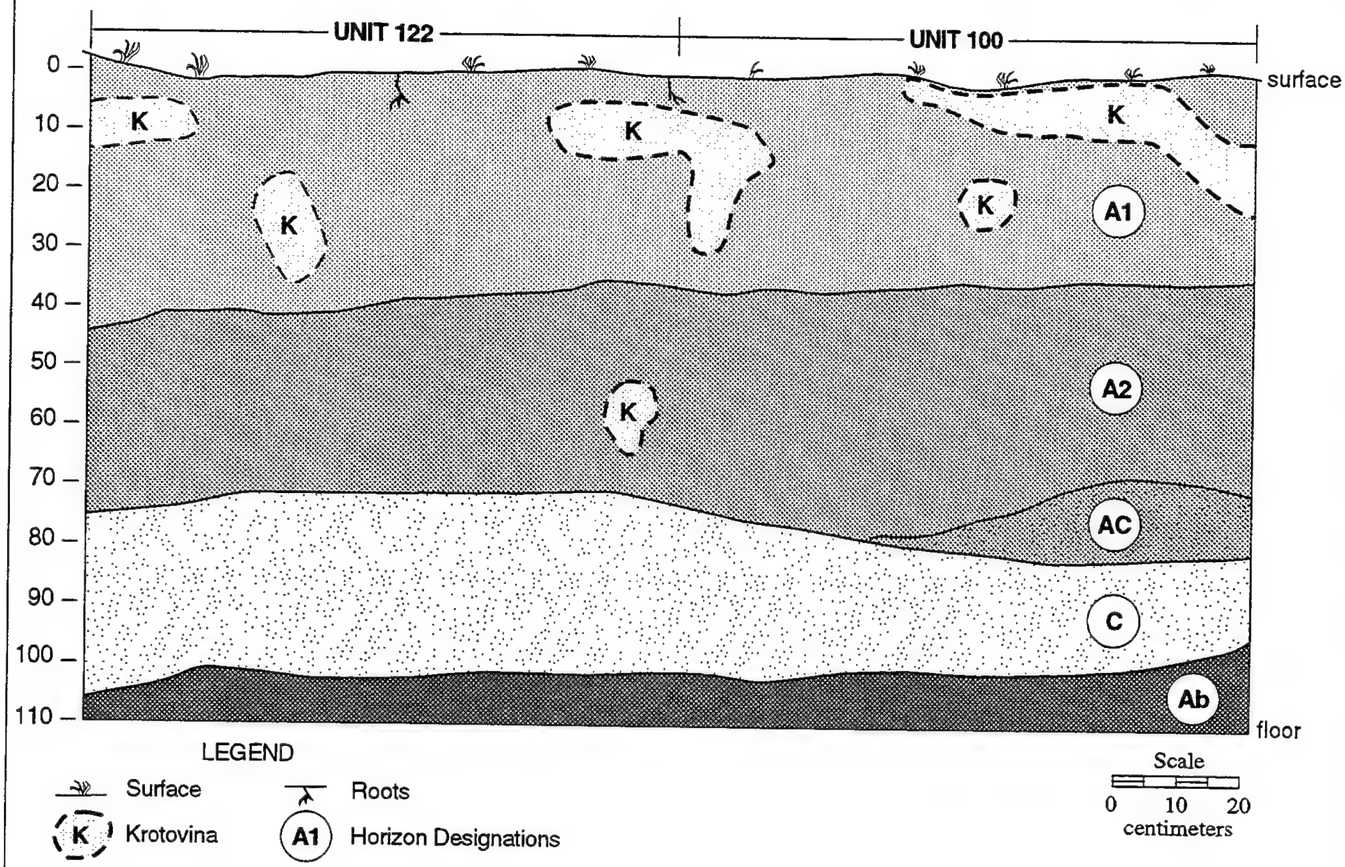
Units 100 and 122

By far, the area with the highest density of shell came from a 1 x 2 m excavation block formed by Units 100 and 122. The units were placed in the southern end of SDI-811 (see Figure 4-1) at the future location of an ejection well emplacement, Well # 1200-1. This area falls into the high density zone delineated by previous research at the site (Byrd et al. 1996).

Unit 100 (1 x 1 m) was excavated down to 110 cm below the surface through all four stratigraphic soil layers described above, including a culturally-sterile buried A horizon (Figure 5-4; Table 5-3). Hand excavations were discontinued at this point, and an auger probe was placed into the bottom of the unit to check for deeper cultural deposits, but none were found. The first 40 cm were composed of the A1 *plowzone*. This layer also contained multiple signs of recent krotovina. Next, the organically rich A2 soil continued from 40 cm down to approximately 70 cm below the surface. The A2 soil was less compact than the A1 layer and contained fewer signs of rodent activity. The lower A2 boundary mottled into the lighter colored, sandy C horizon soil. The mottled AC layer ranged from approximately 70 to 80 cm in depth. The C horizon continued down from 80 cm to approximately one meter below the surface. The remains of a buried Ab horizon, underlying the C horizon, was visible from about 100 cm to the bottom of the excavation unit. The auger probe demonstrated that the Ab horizon rested on a second buried C (Cb) horizon, which ranged in depth from 140 cm to at least 200 cm (not shown in Figure 5-4). Although the probe continued down until encountering the water table at 295 cm, it was difficult to differentiate additional changes in the soil horizons.

A second 1 x 1 m unit (Unit 122) was extended off of the north wall of Unit 100 in order to increase the recovery rate of archaeological material. The deposits encountered in Unit 122 were very similar in structure to those in Unit 100 (see Figure 5-4 and Table 5-3).

Cultural material was uncovered from all of the soil layers except the Ab and Cb horizons. The vertical distribution of cultural material from Unit 100 is representative of this portion of the site. The density of the major material types recovered from Unit 100 is presented in Table 5-4. The density values were calculated by dividing the number or weight of a specific artifact type by the volume of excavated material. Counts were used for flaked stone material while weights were used for bone, shell, and fire-affected rock in accordance with common archaeological practice.



Photograph not to scale

Figure 5-4. East Wall Profile of Units 100 & 122 Displaying Stratigraphic Layers and Signs of Disturbance

Table 5-3. Strata Description of Units 100/122

Strata/ Horizon	*Depth (cm)*	*Color*	*Description*
A1	0-34	10YR2.5/2d; 2/1m	Dark grayish brown, very fine dry sandy loam; very compact soil; plowzone
A2	34-75	10YR3/2d; 2/1m	Dark grayish brown, sandy loam with decreasing compaction and root activity with depth
C	75-105	2.5Y3.5/2 (damp); 3/2m	Light gray/brown fine sandy silt; medium compaction and very few roots (note: some molting of A2 and C within Unit 100 profile)
Ab	105-139	10YR3.5/2 (damp); 3/2m	Dark brown hard compacted loam; slightly moist
Cb	139-185+	2.5Y3/2m	Fine gray brown sand

Table 5-4. Density of Cultural Material in Unit 100

Depth (cm)	*Flaked Stone (ct/m^3)*	*Bone (g/m^3)*	*Shell (g/m^3)*	*FAR (g/m^3)*
0-20	135	11	1,029	2,645
20-40	85	11	1,770	7,297
40-50	140	40	3,461	25,566
50-60	100	120	4,780	4,092
60-70	80	21	4,731	984
70-80	30	14	1,547	783
80-90	30	3	824	167
90-100	90	7	789	126
100-110	–	1	121	–

The percentage of major material types by depth is displayed graphically in Figure 5-5. The percentage of flaked stone artifacts for each depth was calculated as the number of flaked stone artifacts recovered from an excavation level divided by the total number of flaked stone artifacts for the unit. The bone, shell, and fire-affected rock percentages were calculated in the same fashion, based on the weights recovered from each depth divided by the total weight for the unit. In order to base the density and percentage values on a systematic collection strategy, only 1/4" screened material and point provenienced artifacts were used in the calculations. The same methods were used to generate the tables and figures for Units 109, 115, and 116 (see below).

Units 100 and 122 have the highest density of shell remains from the entire site. Both units also contained relatively high densities of fire-affected rock, especially within the 40-50 cm level.

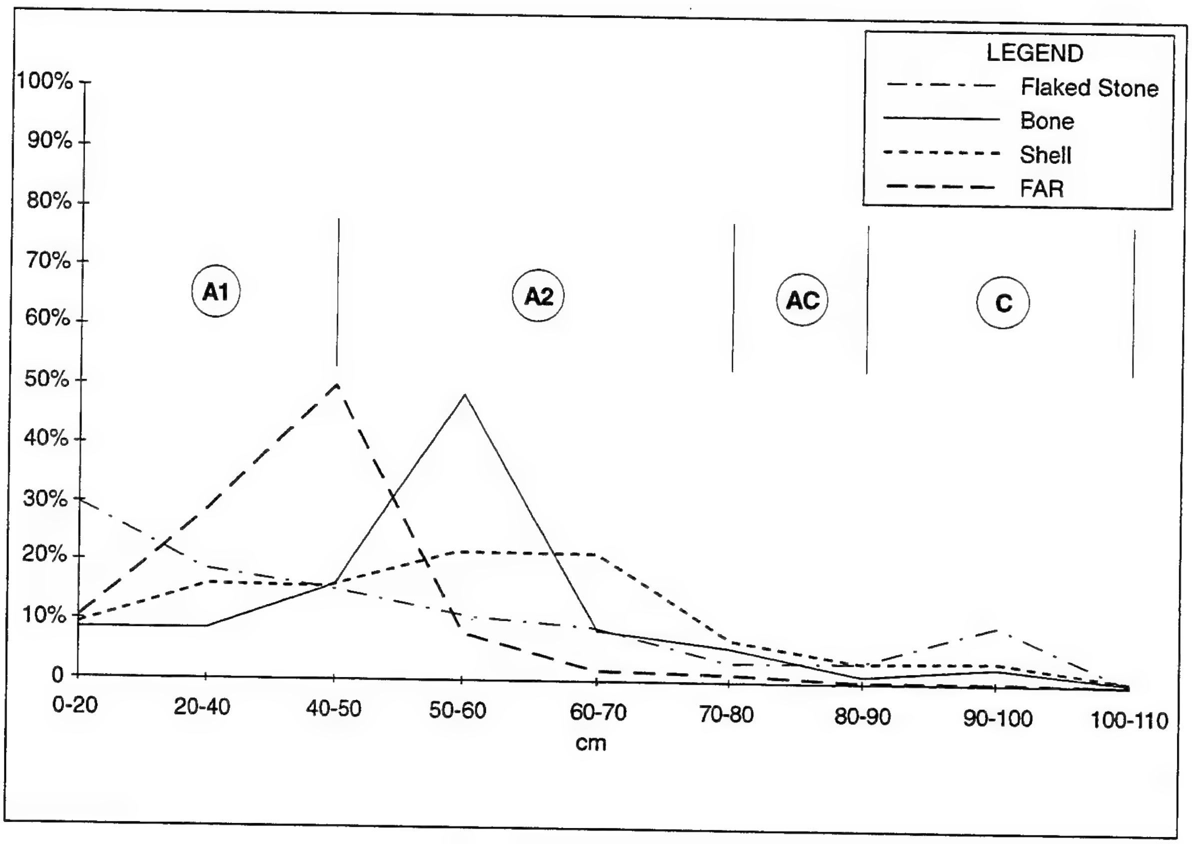


Figure 5-5. Vertical Distribution of Material in Unit 100

Unit 109

Unit 109 (see Figure 4-1), a 1 x 1 m unit placed approximately 650 feet from the southern end of the APE, contained a dense pocket of cultural material. The unit was excavated to 150 cm in depth, at which point recovery of cultural material was almost non-existent. Hand excavations were discontinued, and an auger probe was placed into the bottom of the unit to check for deeper cultural deposits, but none were found. The soil stratigraphy of this unit (Figure 5-6; Table 5-5) is very similar to that seen in Units 100 and 122. The top 40 cm correlates with the A1 rich organic compact soil associated with the plowzone. The A2 layer extends from 40 cm to approximately 60 cm below the surface. Both of these layers showed some signs of root disturbance, but very little rodent activity (e.g., krotovina). Below A2, there was a rather thick transitional AC layer, up to 40 cm thick in the western half of the unit. The C horizon then continued down to about 135 cm below the surface. The C horizon was heavily disturbed by krotovina, especially between 90 and 120 cm below the surface. Underneath the C, a buried Ab horizon was visible from approximately 135 cm to the bottom of the excavation unit at 150 cm. An auger probe excavated into the bottom of the unit hit the water table at 215 cm below the surface.

The composition of cultural material from Unit 109 (Table 5-6, Figure 5-7) differs significantly from Units 100 and 122. Unit 109 has the highest density of animal bone from the entire site. It also has a slighter higher density of flaked stone artifacts, but much lower density of shell than Units 100 and 122. The majority of bone was recovered from between 70 and 110 cm in depth, which correlated with the AC and C horizon layers. The same holds true for the shell remains. The lithic assemblage and the fire-affected rock, on the other hand, are concentrated in the A2 soil horizon. The flaked stone was recovered in greatest numbers between approximately 40 and 70 cm in depth while the fire-affected rock had a dramatic spike between 50 and 60 cm.

The buried A horizon soil was virtually sterile, and the few remains that were recovered from the lowest regions of the unit probably originated from the deposits lying above the Ab layer.

A single radiocarbon date was run from a shell sample taken from 100-110 cm below the surface, correlating with the C horizon (see Section 5.3 for more details). The sample has a 1-sigma calibrated age of 20 B.C. to A.D. 150. It is interesting to note that this date is significantly older than anything from Unit 122, including the date from the C horizon deposit (see Table 5-11 below). The two discrete middens, therefore, were not contemporaneous. This reinforces the complex nature of both the horizontal and vertical variations within the site structure.

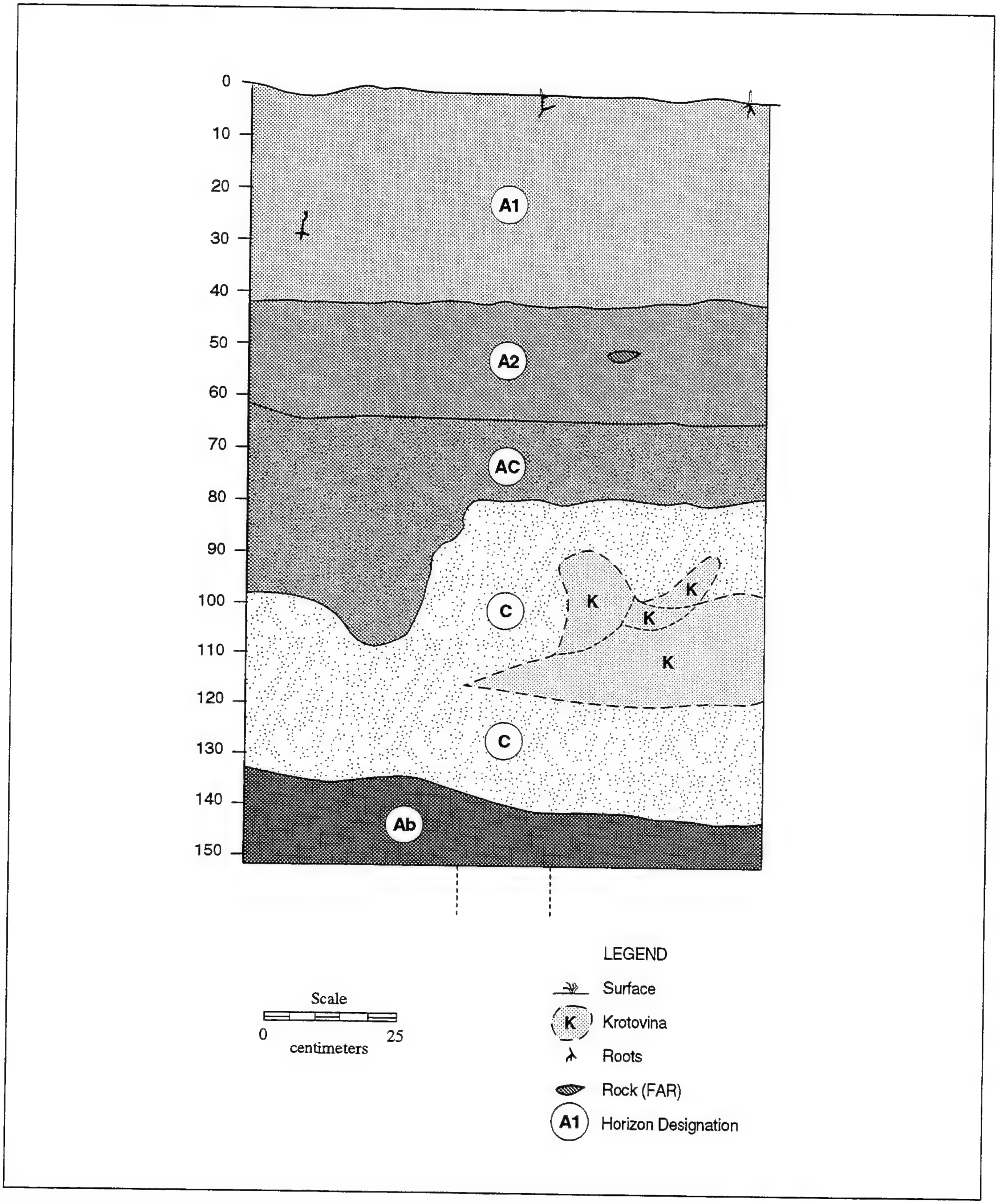


Figure 5-6. North Wall Profile of Unit 109 Displaying Stratigraphic Layers and Signs of Disturbance

Table 5-5. Strata Description of Unit 109

Strata/ Horizon	*Depth (cm)*	*Color*	*Description*
A1	0-40	10YR3/2d; 2/1m	Dark grayish brown, fine-grained sandy loam; low amounts of root disturbance; plowzone
A2	40-62	10YR3/2d; 2/1m	Dark grayish brown, sandy loam, low amounts of root disturbance
AC	62-79	10YR2/2m	Mottled deposit of dark brown sandy loam with lighter colored sand; moderate amounts of krotovina
C	79-137	10YR3/2m	Light brown coarse-grained loamy sand; friable
Ab	137-170+	10YR2/1.5m	Dark brown sandy loam with silt/clay content; compact and moist

Table 5-6. Density of Cultural Material in Unit 109

Depth (cm)	*Flaked Stone (ct/m^3)*	*Bone (g/m^3)*	*Shell (g/m^3)*	*FAR (g/m^3)*
0-20	105	1	1	476
20-40	95	11	–	442
40-50	520	24	–	520
50-60	390	55	–	11,614
60-70	430	169	44	2,097
70-80	260	203	134	1,344
80-90	130	379	128	819
90-100	240	300	153	–
100-110	120	245	256	151
110-120	20	133	64	–
120-130	60	32	42	–
130-140	10	85	3	–
140-150	–	–	–	–

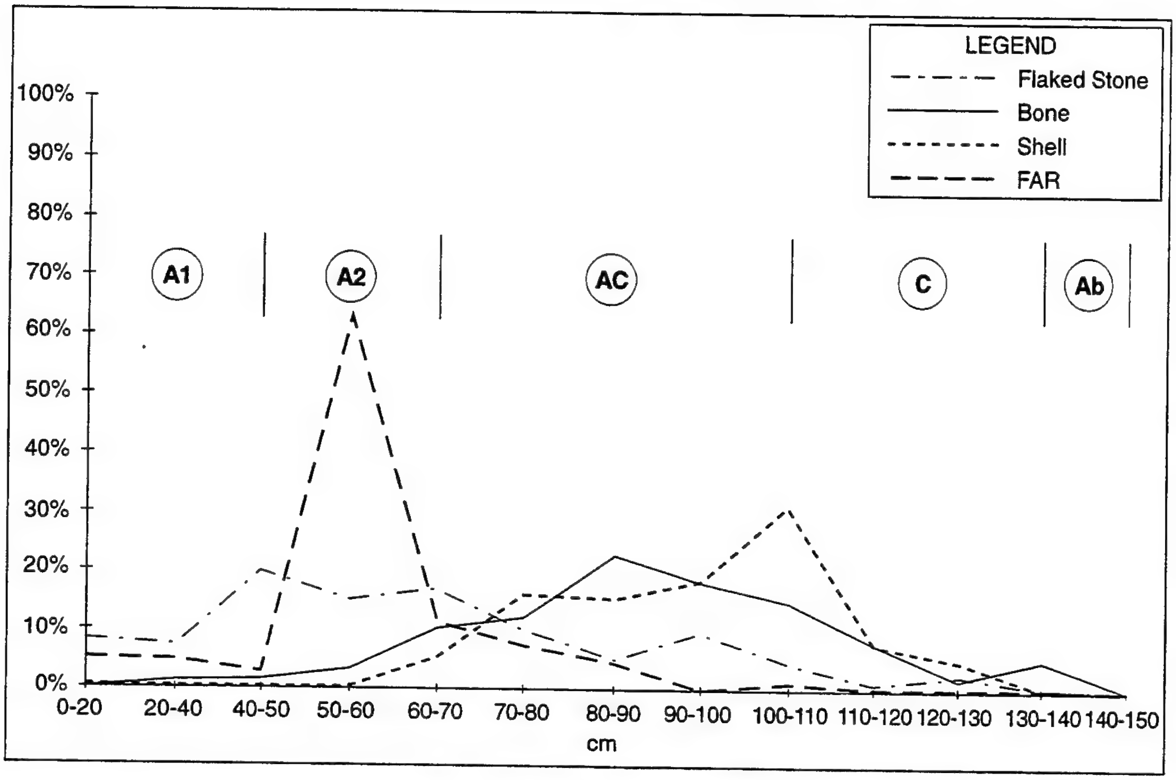


Figure 5-7. Vertical Distribution of Material in Unit 109

Fire-Affected Rock Areas

Two areas of the site contained dense scatters of fire-affected rock in association with other cultural material.

FAR I

A concentration of fire-affected rock was discovered within the 40-50 cm excavation level of Unit 107. This area was expanded into a 6 m^2 excavation area with the inclusion of Units 113, 114, 115, 119, and 120. Unit 115 was excavated down to 130 cm below the surface, at which point recovery of cultural material was almost non-existent. Hand excavations were discontinued, and an auger probe was placed into the bottom of the unit to check for deeper cultural deposits, but none were found. Unit 115 (Figure 5-8; Table 5-7) is representative of the general soil stratigraphy in this area of the site.

The first 40 cm is composed of the compact A1 plowzone. This layer displayed a large amount of root disturbance and a minor amount of rodent activity. The A2 soil layer, which held the fire-affected rock concentration, ran from 40 cm to approximately 80 cm in depth. Below this, the mottled AC layer continued down until a C horizon was encountered at approximately 110 cm below the surface. The C horizon continued to the bottom of the excavation unit at 130 cm. Minor to moderate levels of root and rodent disturbance were seen throughout the excavation unit. An auger probe was placed in the bottom of the unit and was excavated down until encountering the water table at 230 cm in depth. The auger

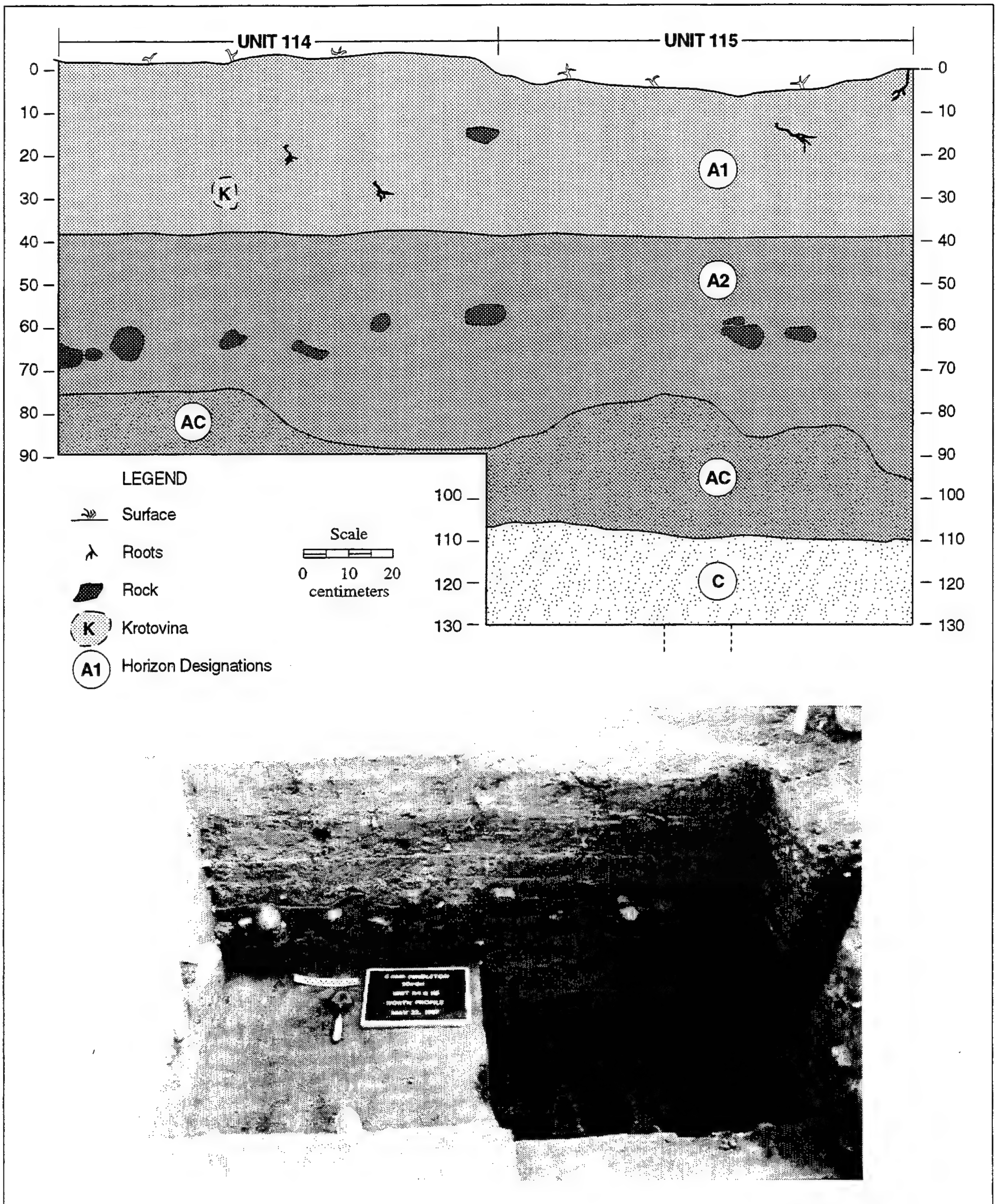


Figure 5-8. North Wall Profile of Units 114 & 115 Displaying Stratigraphic Layers and Signs of Disturbance

Table 5-7. Strata Description of Unit 115

Strata/ Horizon	Depth (cm)	Color	Description
A1	0-40	10YR2.5/1d; 2/1m	Dark grayish brown, fine-grained sandy loam; very compact; plowzone
A2	40-80	2.5Y2/0-10YR 2/1m	Dark grayish brown, sandy loam; moderate to low compaction; high amounts of fire-affected rock
AC	80-110	10YR2/2m	Mottled deposit of dark brown sandy loam with lighter colored sand
C	110-160	10YR3/2m	Light brown sandy low; friable; low compaction
Ab	185-250+	10YR2/2m	Dark brown silty loam with increase in clay and dampness with depth

encountered an Ab horizon in association with cultural material at approximately two meters below the surface (discussed below).

Dense concentrations of fire-affected rock (Figures 5-9, 5-10) were encountered throughout the 6-square-meter excavation area between 40 and 80 cm below the surface. The fire-affected rock was composed of small to medium-sized cobble fragments.

These cobbles were primarily granitic, metamorphic, volcanic, and quartzite rocks, which are the types of cobbles found naturally in the local area.

The placements of the rocks do not form any recognizable pattern, such as a circular impression of a hearth, nor do they appear to be part of a pit feature such as those described for ASM's Unit 1 (Byrd et al. 1996). The scattered patterns of fire-affected rock probably represent the clean-out of hearths or roasting pits within the general vicinity.

FAR I also contained a few flaked stone artifacts, debitage, two tarring pebbles (of the six found in the entire site), and a fair amount of animal bone (Table 5-8, Figure 5-11). Surprisingly few shell fragments were recovered. In fact, FAR I had the lowest density of recovered shell from the entire site.

A small charcoal sample was recovered from within the rock concentrations, 60-70 cm below the surface (see Section 5.3 for more details). The sample has a 1-sigma calibrated age of B.C. 1200 to 835.

FAR II

A second concentration of fire-affected rock was uncovered in Unit 104, about 150 feet south of FAR I. The area was expanded into a 2 x 2 m excavation area with the additions of Units 116, 117, and 118. Unit 116 was excavated to 150 cm below the surface, at which point recovery of cultural material was almost non-existent. Hand excavations were discontinued,

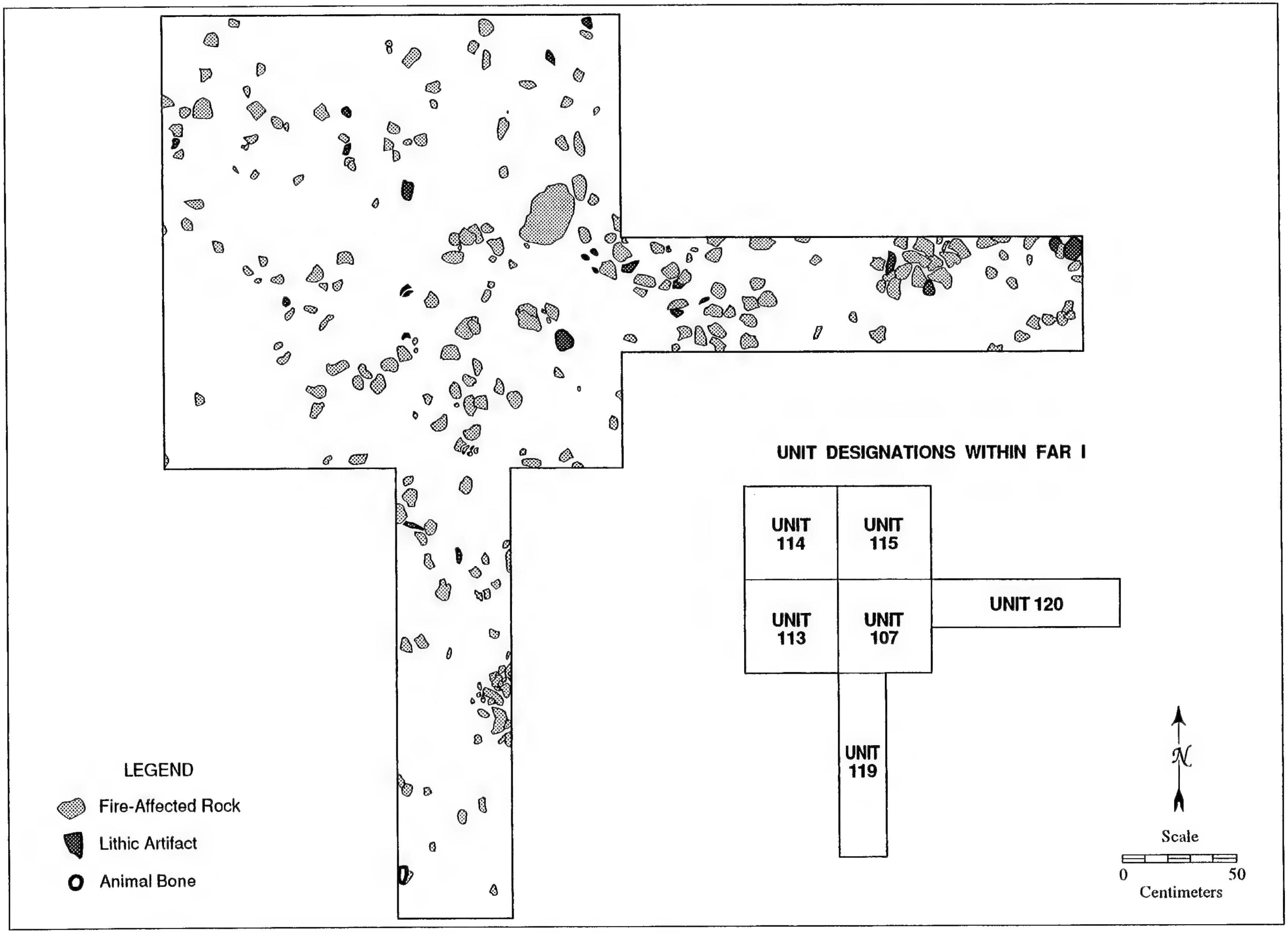


Figure 5-9. Planview of Fire Affected Rock Area I (FAR I) at 50 cm Below the Surface

Figure 5-10. Fire Affected Rock Area (FAR I) at 50 cm Below the Surface Within Units 107, 113, 114, & 115

Table 5-8. Density of Cultural Material in Unit 115

Depth (cm)	*Flaked Stone (ct/m³)*	*Bone (g/m³)*	*Shell (g/m³)*	*FAR (g/m³)*
0-20†	40	9	5	2,500
20-40†	20	4	10	3,500
40-50	320	31	4	53,973
50-60	370	93	11	43,289
60-70	430	623	–	65,982
70-80	220	222	2	15,482
80-90	420	221	4	21,779
90-100	200	106	–	4,491
100-110	130	153	–	2,011
110-120	40	75	9	–
120-130	10	18	–	–

† 1/2" screened material only.

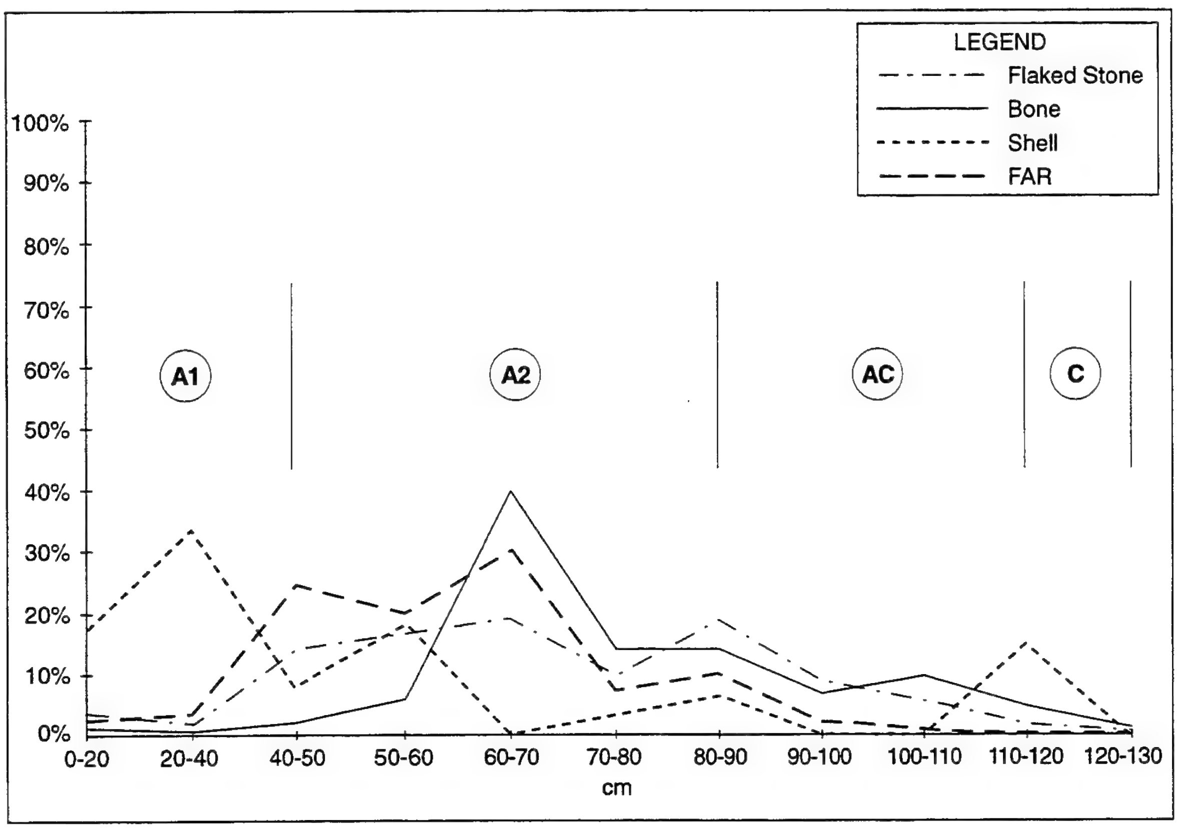


Figure 5-11. Vertical Distribution of Material in Unit 115

and an auger probe was placed into the bottom of the unit to check for deeper cultural deposits, but none were found. Unit 116 (Figure 5-12; Table 5-9) is representative of the stratigraphy in this area of the site.

The top 35 cm of Unit 116 was composed of the A1 soil, with moderate root and rodent disturbance. The A1 layer was replaced by the A2 layer, which continued down to around 80 cm below the surface. The fire-affected rock concentration was confined within A2. The A2 soil gives way to a transitional AC stratum. Small amounts of root disturbance extended down to approximately 120 cm below the surface, which correlates to the beginning of the C horizon. The C horizon continued down to the bottom of the excavation unit. An auger probe was placed in the bottom of the unit and was excavated down to the water table at 270 cm below surface. A buried Ab horizon soil with cultural material was encountered between 240 and 270 cm in depth (discussed below).

The rock scatters within FAR II (Figure 5-13) extended across the entire 2 x 2 m excavation area, but were confined to the A2 soil horizon between 40 cm and 75 cm in depth. The highest density of burnt rock (227,518 g/m^3) was recovered from the 60-70 cm level. As in the case with FAR I, the burnt rocks within FAR II were composed of fractured cobbles of locally available material, and their placement does not display any recognizable pattern. They appear to be the scattered remains of cleaned-out hearths or fire-pits.

Besides fire-affected rock, FAR II yielded high amounts of debitage, animal bone, shellfish, and some worked lithics (Table 5-10, Figure 5-14). The debitage and bone was fairly evenly distributed between 20 and 110 cm below the surface. Bone levels drop off once the C horizon soil was reached. Most of the shellfish remains were recovered from levels below the dense fire-affected rock concentrations. In fact, the highest density of shellfish came from 100-110 cm below the surface.

A few fragments of *Chione* shell were recovered from the 60-70 cm excavation level. Radiocarbon analysis of this sample yielded a 1-sigma calibrated date of B.C. 210 to 20 (see Section 5.3 for more details).

Discussion

The scatters of fire-affected rock probably represent the clean-out of hearths or other similar features. In addition to burnt rock, these areas were used as a dumping ground for food remains, broken tools, and other discarded materials.

Although geomorphological evidence suggests that the rock assemblages may have experienced minor post-depositional movement from both agricultural practices and bioturbation (see Appendix E), the well-defined horizontal distribution of the fire-affected rocks indicates an overall high degree of integrity.

FAR I and FAR II have very similar structures in terms of types and distribution of burnt rocks. The two areas, however, have different archaeological signatures, primarily in the recovery of shellfish remains. FAR I had extremely low densities of shellfish remains compared to the rest of the site while FAR II had relatively high densities of shellfish.

FAR I and FAR II also differ in age. FAR I has a 1-sigma calibrated age of B.C. 1200 to 835 while the FAR II has a date of B.C. 210 to 20. Not only are these two dates very different from each other, but they also differ considerably from the midden dates discussed above. A similar fire-affected rock deposit was unearthed during ASM's excavations at SDI-811 (Byrd et al. 1996). They discovered a loose concentration of cobbles, charcoal, and fire-affected rock (Feature B) between 60 and 90 cm below the surface of Unit 1. They suggested that this concentration represented either an intact pit hearth or "the clearings from a hearth that were disbursed along an irregular surface" (Byrd et al. 1996:77). A *Donax* sample from the feature area yielded a 2-sigma calibrated date of A.D. 730-970. Their description of Feature B matches well with the findings at FAR I and FAR II. Feature B probably does not represent an intact pit hearth, but appeared to do so because of the small excavation exposure (1 x 1 m unit). It is more likely that Feature B, like FAR I and FAR II, was the result of hearth clear-outs in the nearby area. The difference in ages of FAR I, FAR II, and Feature B is notable and indicates that SDI-811 has been the subject of repeated occupations (see Section 5.3 for more details).

Deeply Buried Cultural Deposit

A deeply buried cultural deposit was discovered during the last three days of the field project. An auger probe placed into the floor of Unit 115 recovered cultural material from an Ab horizon, beginning around 2 meters below the surface. This was the first indication that cultural material within an Ab exists at the site. A backhoe excavated below the floor of Unit 115 in order to expose the buried deposit, but excavations halted around 2.5 meters below the surface when the water table was encountered. The cultural deposit, however, appears to continue below the water table. The buried deposit was located below the area being affected by the pipeline project and was considered beyond the scope of the project; it was, therefore, possible to collect only a few small samples from the buried component before the unit flooded with water. Various shell species were recovered as well as some animal bone and a few rock fragments. An auger probe within Unit 116 (about 150 feet south of Unit 115) uncovered a similar deep deposit beginning at 240 cm below the surface and continuing to at least 270 cm, the level of the water table.

A sample of shell recovered from 240 cm below the surface of Unit 115 yielded a 1-sigma calibrated date of B.C. 2270 to 2005. The deeply buried cultural deposit in Unit 115 is the oldest yet found at the Red Beach site.

Approximately 72 grams of shellfish were recovered from the Ab horizon of Unit 115. Over 92 percent of the specimens, by weight, were Reversed Jewel Box (*Pseudochama exogyra*), a rocky shore inhabitant. This species was not encountered in the upper deposits of the site. Geoarchaeological evidence indicates that sea levels were approximately 30 m lower than today's level at the beginning of the Early Holocene and that the rapid sea level rise during the Late Pleistocene and Early Holocene created mainly rocky shorelines along the coastal zone of Camp Pendleton (Inman 1983; Reddy and Byrd 1997). When the rate of the rising ocean slowed during the last 4,000 years, large expanses of sandy beach replaced most of the rocky shorelines (see Inman 1983 and Reddy and Byrd 1997 for more information). The presence of rocky-shore species from the buried component suggests that rocky-shore conditions still prevailed in the Las Flores drainage around 4,000 years ago.

Table 5-9. Strata Description of Unit 116

Strata/ Horizon	*Depth (cm)*	*Color*	*Description*
A1	0-35	10YR3/2d; 2/1m	Grayish brown, silty clay; very compact; plowzone
A2	35-80	10YR3.5/2d; 2/1m	Yellowish brown, sandy silt/clay; moderate to low compaction; high amounts of fire-affected rock
AC	80-120	10YR2/2m	Mottled deposit of grayish brown silty clay with lighter colored clay/sand
C	120-240	10YR3/2m	Light brown clay/sand with high content of small gravel
Ab	240-270+	10YR2/2m	Dark brown sandy clay

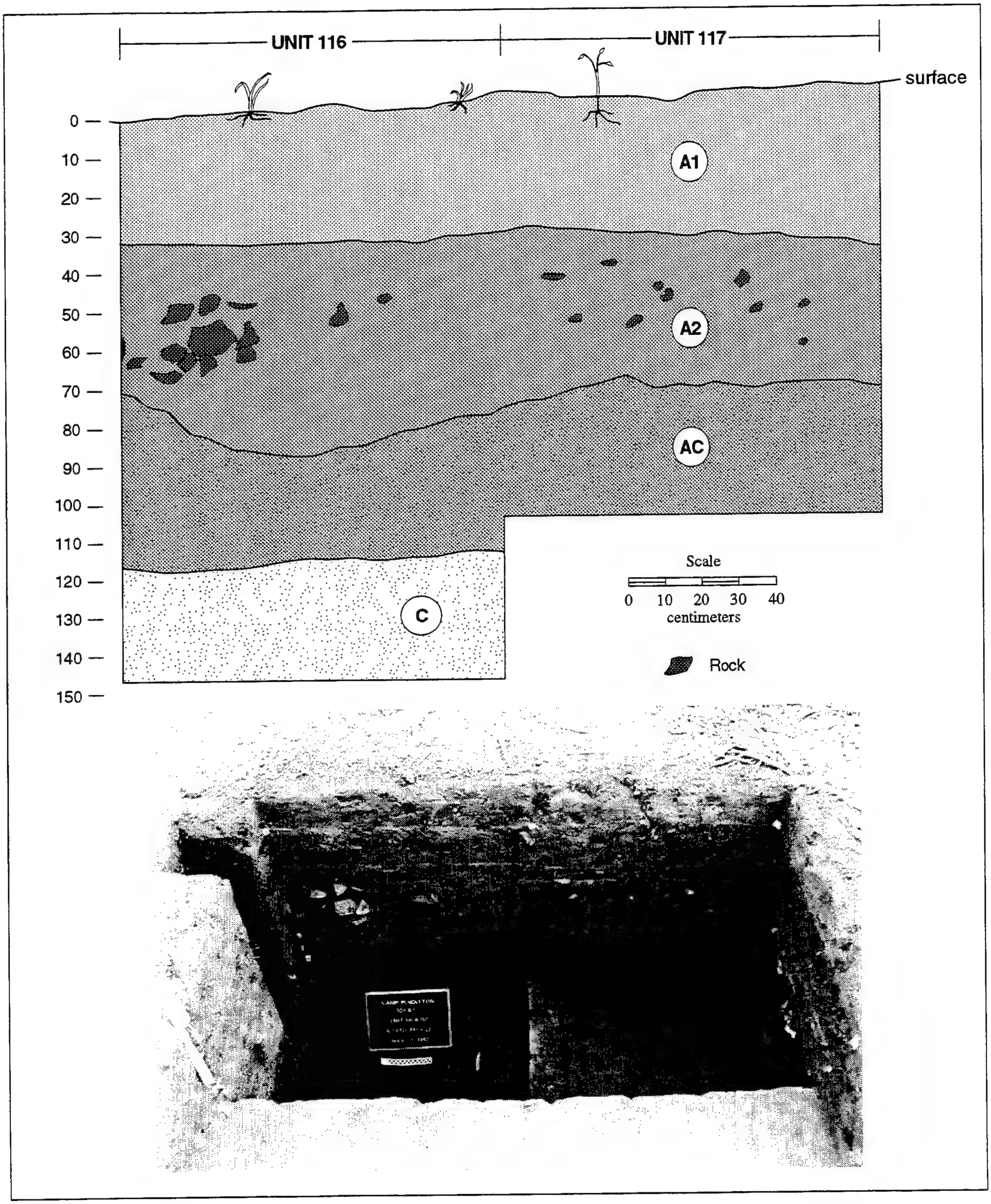


Figure 5-12. North Wall Profile of Units 116 & 117 Displaying Stratigraphic Layers and Signs of Disturbance

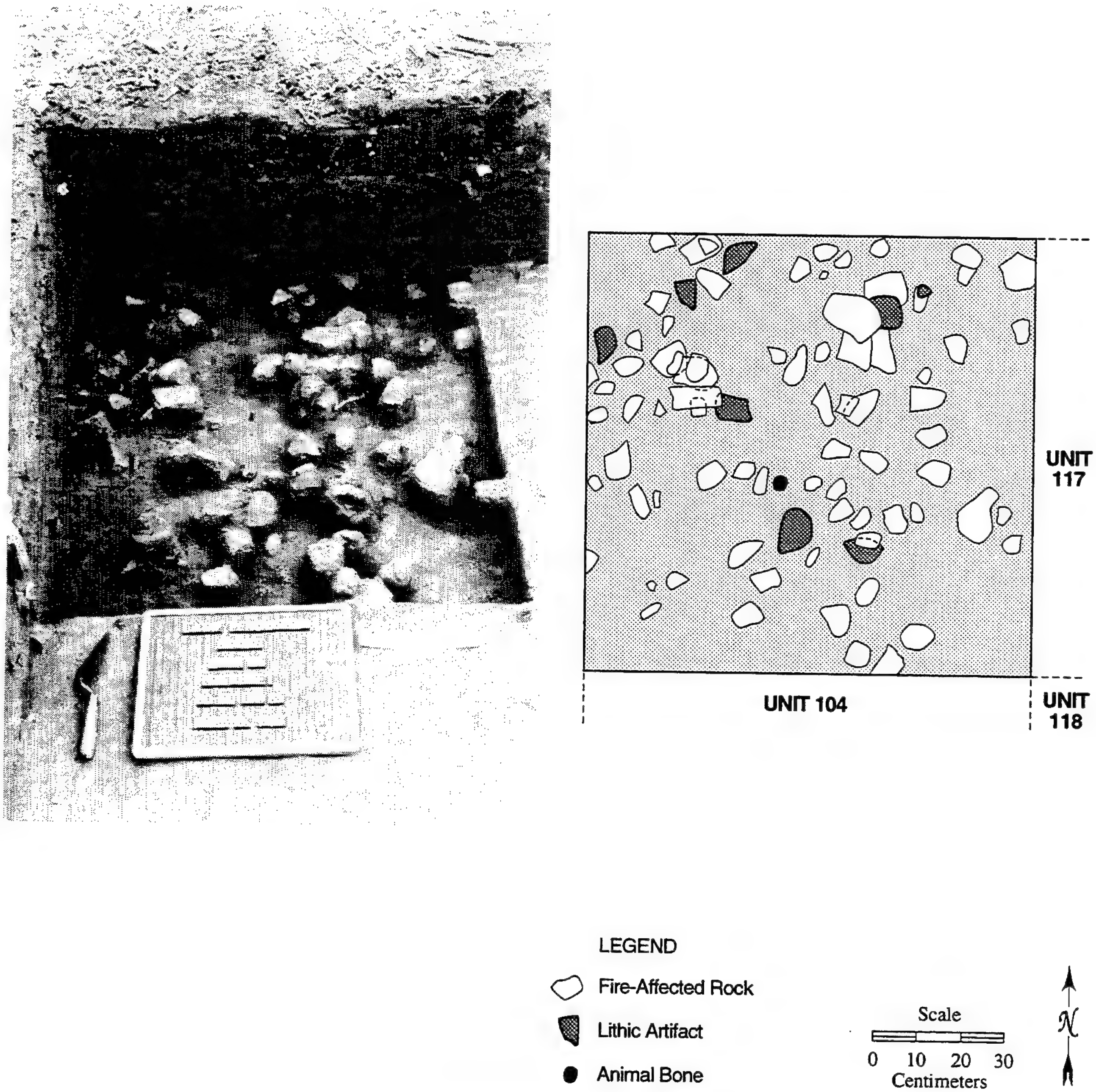


Figure 5-13. Fire Affected Rock Area (FAR II) at 60 cm Below the Surface Within Unit 116

Table 5-10. Density of Cultural Material in Unit 116

Depth (cm)	*Flaked Stone (ct/m³)*	*Bone (g/m³)*	*Shell (g/m³)*	*FAR (g/m³)*
0-20†	75	–	37	1,178
20-40†	80	43	17	13,800
40-50	270	269	17	20,182
50-60	240	111	87	118,323
60-70	250	153	353	227,518
70-80	110	227	513	22,176
80-90	150	181	319	1,168
90-100	120	159	334	–
100-110	100	302	1,123	291
110-120	50	39	248	–
120-130	60	12	131	–
130-140	30	58	–	–
140-150	130	–	23	–

†1/2" screened material only.

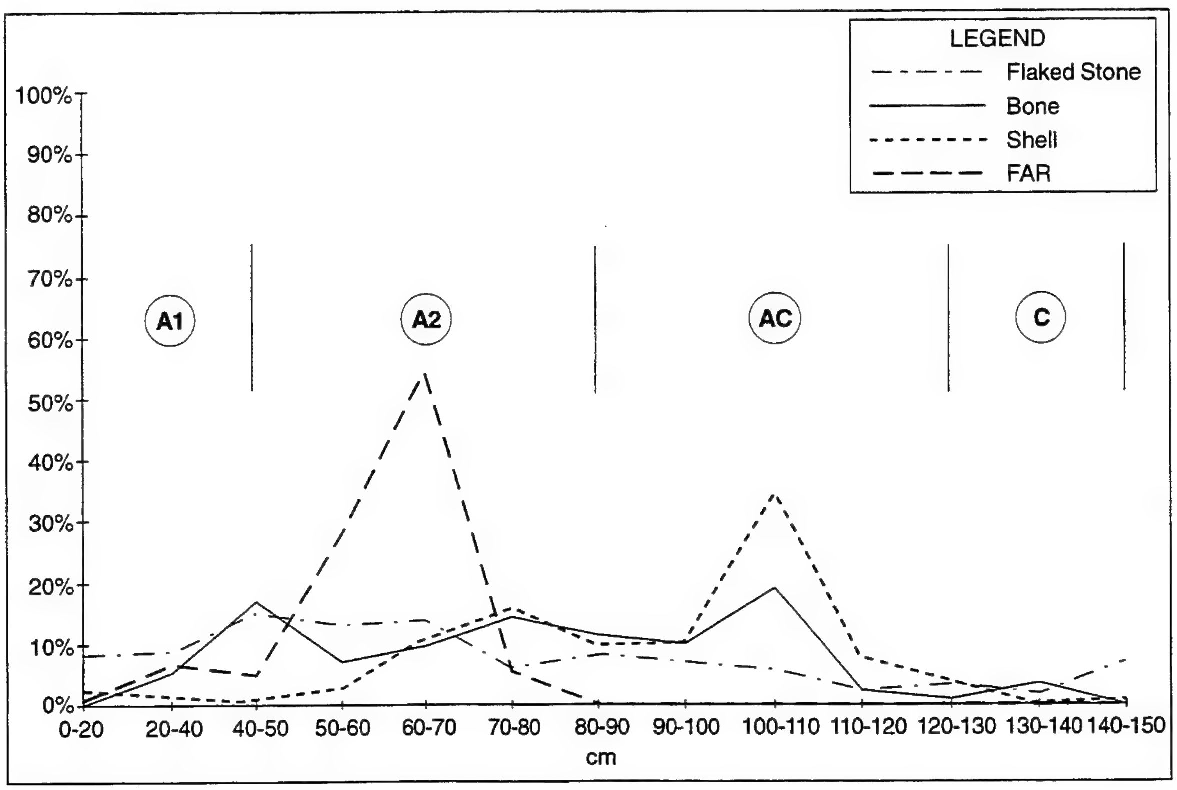


Figure 5-14. Vertical Distribution of Material in Unit 116

5.3 SUMMARY OF CHRONOLOGY AND TEMPORAL PLACEMENT

Radiocarbon Dates

Eight samples from the current data recovery project at SDI-811 were submitted to Beta Analytic, Inc. in Florida, for radiocarbon analysis and yielded conventional dates ranging from 1810±70 years B.P. to 4290±80 years B.P. (Table 5-11, Figure 5-15). The dates were derived from four samples of *Donax*, one sample *Chione* shell, one Pectinidae shell sample, one *Pseudochama* shell, and one sample of charcoal. In addition, previous investigations (Byrd et al. 1996) yielded three dates from the site and three dates from the Las Flores Creek profile (Table 5-11). The "Conventional C-14" ages given in Table 5-11 were adjusted by Beta Analytic for C13/C12 ratios and for local reservoir effects, where applicable (see Appendix G for more details).

The radiocarbon dates indicate that the site had been reoccupied over a long period. The impression is of shifting occupation or activity areas across the site through time. The most recent occupation appears to be the upper A horizon deposits in Units 100 and 122. Three virtually identical dates from the upper midden match well with those derived from ASM's Units 1 and 2 (Byrd et al. 1996). Unit 2 is located within the same vicinity as Units 100 and 122; therefore, the similarity in dates is not surprising. Unit 1, however, is located near FAR I and FAR II and, yet, the latter areas are significantly older than the deposits in Unit 1.

The lower cultural deposits of Unit 100 and 122 differ in age from the upper deposits. A sample taken from within the C horizon yielded a 1-sigma calibrated range of A.D. 280 to 495. This suggests that the cultural material in the C horizon originated from an earlier occupation than the material in the A horizon. In other words, the lower deposit has not "trickled down" from the upper deposits due to bioturbation and other disturbances.

Although the soil stratigraphy of Unit 109 matches well with Units 100 and 122, the date of the cultural deposit in the C horizon appears to be older than the corresponding deposit in the latter units. The sample from Unit 109 yielded a 1-sigma calibrated date of B.C. 130 to A.D. 250. This date overlaps with FAR II.

Although FAR I and FAR II are both concentrated in the A2 horizon, samples derived from each of the areas differ significantly in age. FAR I yielded a 1-sigma calibrated date of B.C. 1200-835, falling into the Late Archaic, while FAR II yielded a date of B.C. 210-20, falling near the transition between the Archaic and the Late Prehistoric periods.

Finally, a sample of shell recovered from within the Ab horizon of Unit 115 has a 1-sigma calibrated age of B.C. 2270 to 2005. This is the oldest cultural deposit, to date, from the Red Beach site.

Samples from the cultural material in the A horizon range from A.D. 905 to B.C. 1200 (based on the 1-sigma calibrated ranges). This wide range of dates would seem to imply that there was long-term stability of the soil landscape over a 2,000-year period. According to the radiocarbon dates, however, the two dates from C horizon deposits are younger than some

Table 5-11. Radiocarbon Dates from CA-SDI-811

Unit	*Depth*	*Material*	*Beta #*	*Conventional C-14 Age*	*Calibrated Results (1 Sigma)*	*Calibrated Results (2 Sigma)*	*Comments*
114	60-70 cm	Charcoal	106703	2850±130 B.P.	B.C. 1200-835	B.C. 1395-795	FAR I
116	60-70 cm	Shell (*Chione* spp.)	106704	2670±70 B.P.	B.C. 210-20	B.C. 350- A.D. 70	FAR II
122	0-20 cm	Shell (*Donax* spp.)	106705	1830±60 B.P.	A.D. 710-875	A.D. 665-960	Dense midden
122	50-60 cm	Shell (*Donax* spp.)	106706	1810±70 B.P.	A.D. 720-905	A.D. 665-1000	Dense midden
122	60-70 cm	Shell (*Donax* spp.)	106707	1820±60 B.P.	A.D. 720-885	A.D. 670-970	Dense midden
122	80-90 cm	Shell (*Donax* spp.)	107437	2230±80 B.P.	A.D. 280-495	A.D. 175-605	Dense midden
109	100-110 cm	Shell (Pectinidae)	107438	2510±70 B.P.	B.C. 20- A.D. 150	B.C. 130- A.D. 250	Midden area
115	240 cm	Shell (*Pseudochama* spp.)	106708	4290±80 B.P.	B.C. 2270-2005	B.C. 2405-1890	Ab horizon
1	40-80 cm	Shell (*Donax* spp.)	84170[1]	1725±70 B.P.	A.D. 635-740	A.D. 565-815	Midden area
1	70-80 cm	Shell (*Donax* spp.)	76211[1]	1560±50 B.P.	A.D. 790-905	A.D. 730-970	Feature B
2	80-90 cm	Shell (*Donax* spp.)	76212[1]	1740±80 B.P.	A.D. 615-730	A.D. 530-820	Midden area
IV	100 cm	Low carbon sediment	75375[1]	1800±80 B.P.	–	A.D. 60-420	Las Flores Creek Profile
IIIb	170 cm	Low carbon sediment	76432[1]	2610±80 B.P.	–	B.C. 905-515	Las Flores Creek Profile
Ib	370 cm	Low carbon sediment	75376[1]	4230±60 B.P.	–	B.C. 2920-2610	Las Flores Creek Profile

[1] Submitted by ASM Affiliates (Byrd et al. 1996)

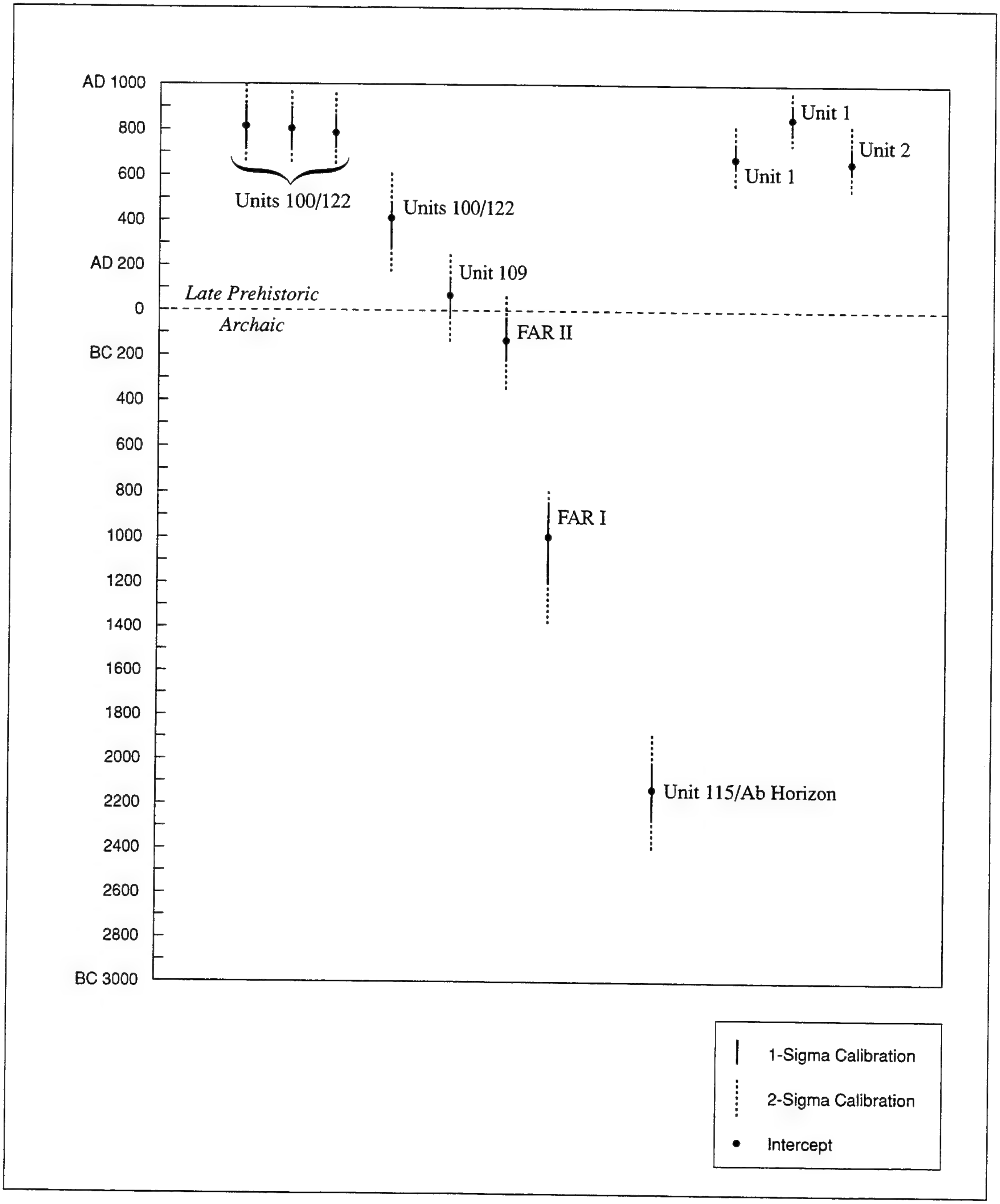


Figure 5.15. Distribution of Radiocarbon Dates from CA-SDI-811

of the A2 horizon deposits. This implies that the soil development across the site was not uniform, resulting in developed A soils of different ages.

Overall, the Red Beach site appears to have been reoccupied over a long period of time, and different areas of the site were used during different time periods. In addition, some locations, such as those around Unit 122, saw multiple occupational episodes. Most of the dates fall into the transition between the Archaic and Late Prehistoric Period or the early part of the Late Prehistoric. Only one date, from the cultural deposit within the Ab horizon, corresponds to around the middle of the Archaic Period. Despite the uniformity of soil stratigraphy across the entire site, the new radiocarbon dates suggest that the depositional history of both cultural and geomorphological deposits was much more complicated than originally anticipated.

Temporally Diagnostic Artifacts

Few temporally diagnostic artifacts were recovered during the data recovery program. Potentially diagnostic artifacts include the metal and glass debris, the ceramic fragments, and one *Olivella* shell bead. The metal and glass debris is probably associated with historic agricultural practices and modern military activities (see Section 5.1 under Site Disturbance for more details).

Four fragments of possible Mission Period brick or tile and forty-three fragments of Tizon Brownware were recovered during the 1997 excavations (see Section 6.3 for more details). Although the radiocarbon samples date no later than A.D. 1000, the presence of these ceramics suggests the possibility of a later, perhaps ethnohistoric occupation.

The shell artifact is a Type A1 (Spire Removed Perpendicular) *Olivella* bead, which is common throughout much of California's prehistory (see Section 8.6) and does not provide further information about the temporal sequence at CA-SDI-811.

5.4 DEFINITION OF ANALYTIC UNITS (AU)

Based on the soil stratigraphy, cultural materials encountered, and radiocarbon dates, five analytic units (Figure 5-16)--representing five different occupational episodes at SDI-811--were defined in order to highlight the spatial and temporal variations within the site. These include three distinct midden deposits as well as both fire-affected rock scatters.

AU 1: Units 100 and 122 (0-70 cm)

Units 100 and 122 (Figure 5-16) had the highest density of shellfish remains from all of the excavation units. There was a distinct drop-off of cultural material after 70 cm in depth. In addition, the material below the A horizon originated from an older occupation, according to the radiocarbon dates. Because of the similarity of dates within the A1 and A2 horizons, the first 70 cm of the deposit in Units 100 and 122 are treated as a single analytic unit (AU 1).

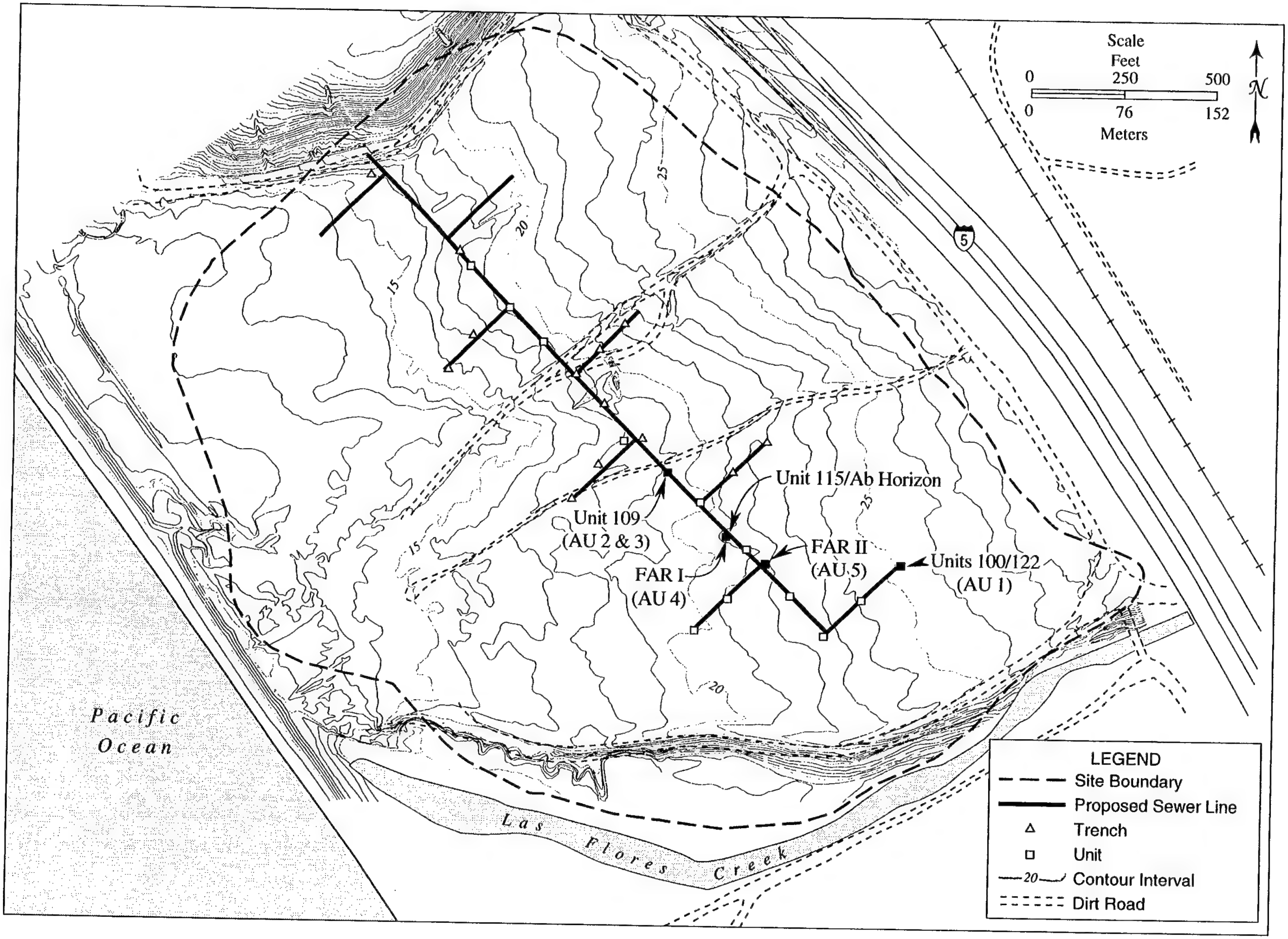


Figure 5-16. Location of Analytic Units at CA-SDI-811

AU 2 and AU 3: Unit 109 (Upper and Lower Deposit)

The vertical distribution of cultural material in Unit 109 demonstrates a bi-modal distribution. Material from the A1 and A2 horizon contains relatively high densities of fire-affected rock and flaked stone artifacts. The material recovered within the AC and C horizon contains relatively high densities of bone and shell. Based on the distribution of material within the unit as well as the stratigraphic profile, we have separated the deposit in Unit 109 into two distinct analytical units—upper deposit (AU 2) and lower deposit (AU 3). The upper deposit contains the first 4 excavation levels (0-60 cm) while the lower deposit corresponds to the last 6 excavation levels (90-150 cm).

AU 4 and AU 5: Fire-Affected Rock Areas (FAR I and FAR II)

The two different concentrations of fire-affected rock (Figure 5-16) are treated as separate analytical units. The fire-affected rock scatters were confined to the A2 horizon. The cultural materials lying below the A2 soils probably originate from an earlier occupational episode; however, this should be confirmed through radiocarbon dating. The material lying above A2 may or may not be related to a later occupation. For now, the analytical unit (AU 4) for FAR I is composed of Units 107, 113, 114, and 115 and will be limited to the material recovered from 40 and 70 cm below the surface. Units 119 and 120, which were also placed within the fire-affected rock area, were not included as part of AU 4 because only the top 50 cm were excavated from these two units due to time constraints.

The analytical unit for FAR II (AU 5) consists of Units 116 and 117, 40-70 cm below the surface. Units 104 and 118 were not included as part of the AU 5 because only the first 50 cm of the units were excavated due to time constraints.

Summary

Five analytic units (Figure 5-16), representing five distinct site occupations, have been defined based on soil stratigraphy, the types and densities of cultural remains recovered, and radiocarbon dates. AU 1 (Unit 100 & 122, 0-70 cm) correlates with a dense midden area with high quantities of *Donax* remains that dates to the Late Prehistoric, approximately A.D. 700-900. AU 2 (Unit 109, 0-60 cm) represents a light midden area dating to sometime after A.D. 150, based on a radiocarbon date from a deeper stratigraphic layer in the unit. AU 3 (Unit 109, 90-150 cm) contains a midden deposit dating between 20 B.C. to A.D. 150. AU 4 (Units 107, 113, 114, & 115; 40-70 cm) represents FAR I and dates to the Archaic period, around B.C. 1200-835. AU 5 (Units 116 & 177, 40-70 cm) represents FAR II, which dates to the transitional period between the Archaic and the Late Prehistoric, around B.C. 210-20.

The detailed analyses of the archaeological material provided in the following chapters utilize the analytic units to explore intra-site patterning. An interpretation of the cultural deposits reflected in the five AU's is provided in Chapter 11.

5.5 HUMAN REMAINS

A single human tooth (Catalog # 395) was identified by the faunal analyst, Dr. Jean Hudson, during her analysis of the faunal material. The burned tooth appears to be a deciduous or immature human molar. The tooth came from Unit 121 at a depth of 80-90 cm below the surface. Unit 121 had an unusual soil stratigraphy that the geomorphologist hypothesized was the result of an old stream channel. No other human remains were recovered during this project.

6 ANALYSIS OF ARTIFACT ASSEMBLAGE

Flaked Stone Artifacts by Sean Hess
Miscellaneous Stone Artifacts by Karen A. Rasmussen
Ceramic Analysis by Judy Berryman

6.1 FLAKED STONE ARTIFACTS

Introduction

This section describes the flaked stone assemblage from SDI-811 and analyzes the artifacts to provide information relevant to the project's Research Design. A primary goal is to help determine what role(s) SDI-811 might have played in regional settlement and subsistence systems during its various periods of occupation from the later part of the Archaic period to the Late Prehistoric.

The following analysis is organized into eight sections. First, each of the research questions covered in the project's Research Design is reviewed and discussed in more detail. Second, previous flaked stone analyses from the Camp Pendleton region are reviewed to establish a broader context for interpreting the site. The third major section identifies data required to address the research questions and the methods used to collect those data. Assemblage content is summarized in the fourth section, while the fifth section covers the organization of the lithic technology found at SDI-811. The sixth and seventh sections address tool use and assemblage diversity, respectively. The final section includes a summary and briefly compares the results of the flaked stone analysis with the analysis of other classes of data.

Review of Research Questions

The Research Design presented a series of questions that can be addressed through analysis of the flaked stone tools.

- *How does the Red Beach site vary in terms of density and diversity of cultural material?*

Artifact densities were addressed earlier in Chapter 5, so the present analysis concentrates on the diversity of the lithic assemblage. Diversity of artifact types, while being closely related to the size of the sample recovered (Jones et al. 1983), is also related to the nature of on-site activities and duration of occupation (Binford 1980, 1982), which provides information relevant to the question of site type and function. Briefly, those sites that are

occupied for relatively long periods of time will have a greater diversity of artifact types than those sites that were occupied for only a short time.

To assess diversity, the flaked stone artifacts from SDI-811 were classified according to the artifact typology developed by ASM Affiliates during previous excavations in the area (Byrd et al. 1995, 1996, 1997). These typologies are discussed more fully under "Information Requirements and Methods". This allowed for the comparison of the number of artifacts per artifact class from SDI-811 to other sites in the area. The number of artifact classes present in each site was compared to the number of recovered artifacts to compensate for the sample size effect.

- *What functional tool types have been recovered from the Red Beach site, and what do they indicate about the nature of on-site activities?*

The previous research questions dealt with aspects of assemblage composition, but it is equally important to understand the ways in which tools were used at SDI-811. Flaked stone tool function, if that can be determined, can provide more information about site type, duration of occupation, and even the types of subsistence activities that took place on the site. As will be shown below, reconstructing tool function is difficult in assemblages dominated by coarse-grained materials like those found at SDI-811.

- *How does the SDI-811 assemblage vary in terms of the amount of flaked stone tool manufacturing, the stages of tool manufacture, types of tools manufactured, and the degree and pattern of artifact curation?*

The bulk of the flaked stone analysis concentrates on these questions, all of which have to do with the organization of lithic technology. Prehistoric knappers throughout the American West appear to have had two main types of end-products in mind when they were manufacturing stone tools: bifaces (including projectile points) and flake tools (Bamforth 1991). While many bifaces may have been made on flake blanks, the objective of bifacial reduction usually was not the production of flakes for use (cf. Kelly 1988), but to shape the objective piece itself. In other words, the form of the objective piece was primary in the mind of the knapper. In flake production, the form of the objective piece was secondary to the form of the flake being removed from it. Flake production may vary from highly structured manufacturing techniques like unidirectional or conical core reduction to unstructured techniques like amorphous/polymorphic core reduction or bipolar reduction (Parry 1994; Parry and Kelly 1987).

The range of manufacturing techniques represented in the flaked stone assemblage at a site has a direct bearing on conclusions about duration of occupation and the site's role in the settlement system. "Manufacturing techniques" refers to any of those methods used by the prehistoric knappers at the Red Beach Site to form stone tools including bifacial reduction, amorphous core reduction, bipolar reduction, and patterned core reduction (i.e., unidirectional core reduction). In western North America, basic manufacturing techniques have been relatively stable throughout time, and one can find evidence of bifacial reduction and amorphous core reduction in the earliest and latest assemblages. Certain specialized manufacturing techniques, including microblade production and prismatic blade production

from conical cores, have more limited spatial and temporal distributions (Ackerman 1992; Parry 1994).

Ethnoarchaeological research has shown that the range of tool types found at a site is proportional to the range of activities performed there and the duration of occupation (Binford 1977, 1980). That is, sites that were occupied for only a short period of time generally have a restricted range of tool types, while sites that were occupied for longer periods of time produce assemblages with greater diversity. The techniques used to manufacture a particular tool vary from type to type, and it is sometimes possible to recognize the distinctive "signatures" of these tool-specific manufacturing techniques. In other words, a wide range of tool types requires a wide range of manufacturing techniques. Therefore, in those sites that have been occupied for a long period of time (which generally contain a wide range of tool types), one should be able to identify the distinctive signatures of a wide range of manufacturing techniques. This assumes, of course, that the occupants of the site are the primary manufacturers of their own tools rather than acquiring them through trade or other methods. For most of the aboriginal societies of the western portion of the United States, this is a reasonable assumption.

Following Binford's (1980) site typology, the widest range of manufacturing techniques should be evident at residential bases, where a wide range of activities occurred over relatively long periods of site occupation. Manufacture would have occurred at field camps, if the group made use of logistical mobility, but to a lesser extent than that seen in residential bases. Manufacture would be rare in most other types of sites except quarries, but these would be easily identified by the presence of lithic raw material in unaltered form, extremely high densities of debitage, and evidence of extremely early stages of manufacture like cobble assaying.

The stages of manufacture at a site can also contribute to an understanding of prehistoric mobility, duration of occupation, and site type. Mobility is an important aspect of site type. Some degree of mobility was typical for almost all North American aboriginal groups, with the possible exception of fully sedentary groups in the American Southwest. This means that groups often did not have the chance to complete all of the tasks required to manufacture a tool at a single site. Stage the manufacture of flaked stone tools, especially bifaces, would have maximized the use-life and efficiency of the utilized raw materials. Bifaces, before they are fully refined and turned into knives or projectile points, can be used as flexible and versatile tools in a number of different tasks, and they may also act as a source of flakes that are then used as tools in and of themselves (Kelly 1988). At the same time, it does not make sense in terms of transportation costs to delay all production to the last minute (Kuhn 1994). Preliminary refinement of objective pieces usually takes place at raw material source areas so that excess weight can be reduced before traveling to another site.

Understanding the stages of manufacture represented at SDI-811 can also contribute to our understanding of site type and duration of occupation. Early stages of manufacture and maintenance (i.e., late stage manufacture) are only likely to co-occur at residential bases or field camps (Binford 1980). Maintenance can happen at shorter duration sites, particularly locations where tools were being used and needed to be repaired to continue functioning during that particular bout of use. However, in those situations in which a group

continuously needs functional tools, they have another alternative - manufacturing new tools using materials on hand for immediate use. The first alternative, repairing a tool so that it can be reused, is one of the hallmarks of *curation*, while the second alternative, making a tool for immediate use, is typical of the *expedient* tool use (Binford 1979; Shott 1997).

While the range of manufacturing techniques and stages present in a site are both related to duration of occupation, other variables may have an influence. One of the most important variables is raw material availability. In those cases where lithic raw materials are available in large quantities, knappers can afford to be somewhat "extravagant" and manufacture new tools for each use (Johnson 1989; Parry and Kelly 1987). On the other hand, when raw material availability is low, conservative reduction techniques that make use of every piece of knappable stone are likely to occur.

Availability has to be judged not only in terms of how much lithic material is accessible to humans in a particular place, but also how suitable that lithic material is for the tasks at hand. Therefore, raw material quality is closely linked to questions about raw material availability (Andrefsky 1994b). In his review of the production of informal and formal tools (i.e. tools representing a low investment of energy vs. those that represent a high investment), Andrefsky (1994a) found that raw material availability and quality interact to strongly influence manufacturing choices. In those cases where high quality raw material is abundant, flaked stone assemblages tend to contain a fairly balanced number of formal and informal tools. High lithic abundance but low quality usually resulted in primarily informal tool production, while low lithic abundance but high quality resulted in primarily formal tool production. In those areas where raw materials were both rare and of poor quality, informal tool production was dominant. Mirroring these sentiments, Eighmey (1996a) hypothesized that raw material quality strongly influenced the degree of refinement or "reduction" at SDI-811, and that this should be visible in differing degrees of refinement in the fine and coarse-grained volcanic debitage.

Because of the importance of raw material quality and availability on the range of tool types produced, attention will be given to raw material selection at SDI-811.

Previous Analyses of Flaked Stone Artifacts in the Camp Pendleton Coastal Zone

This section presents the methods used and conclusions reached in previous studies of flaked stone tools from sites near SDI-811 to establish a context for interpreting the flaked stone artifacts. The ways in which previous investigators have tied lithics to livelihood is given special attention. This review of lithic studies draws on the previous investigations of other sites in the Las Flores area, as well as sites in the San Onofre/San Mateo area about 9 miles (15 km) northwest of the project area (see Chapter 1 for brief site descriptions). The latter sites are included here because the sites are found in a similar environment and because the lithic data are well organized and fairly comparable to data from sites in the Las Flores area. For ease of discussion, the strip of land along the coast that extends to the slope of the San Onofre Mountains within the boundaries of Camp Pendleton is referred to as the Camp Pendleton Coastal Zone (CPCZ).

Although there has been some consistency in the way that classes of flaked stone tools and lithic raw materials have been defined in previous studies, debitage analysis procedures have varied widely. Some projects have taken a typological approach that emphasizes the reduction stage and technique of manufacture manifested in individual pieces of debitage, while others have focused on the range of morphological attributes found in whole debitage assemblages. This lack of standardization inhibits intersite comparisons that might reveal significant patterns in the organization of lithic technology.

Regardless of the problems in data comparability, a relatively consistent pattern has emerged from previous lithic analyses. Flaked stone tool assemblages are dominated by artifacts made of a range of volcanic materials and quartz. Chert tends to be rare, even though it is available from a nearby source area (i.e., the Piedra de Lumbre [PDL] chert source). Tool types commonly found in these sites include cores, utilized flakes, and flake tools, but bifacially worked tools, especially projectile points or well-refined bifaces, are not common. Most of the lithic assemblages indicate on-site manufacture of expedient flake tools derived from locally available, water-rounded cobbles. Evidence of projectile point manufacture and maintenance is infrequent, although it does appear to be more common in some sites than others.

Assemblage Content and Diversity

As is typical in almost all prehistoric sites, debitage is the single most common form of flaked stone artifact, ranging from 87.5 to almost 99 percent of the flaked stone assemblages. Cores made out of locally available volcanic or quartz materials tend to be the most common artifact type following debitage, with percussing tools a close third. Percussing tools, as the category has been developed by ASM Affiliates (see Byrd et al. 1995, 1996, 1997), includes not only conventional pounding tools like hammerstones, but also large, unrefined flaked stone artifacts like choppers. Utilized debitage have been found in almost all of the sites, as have unifacially retouched tools and bifacially retouched tools. Most of the bifacially retouched tools are fragmentary projectile points, many of which are made out of undifferentiated chert or PDL chert. Biface fragments made out of volcanic materials have been found in a few sites (e.g., SDI-10728 [Byrd et al. 1997]), as well as quartz projectile points (e.g., SDI-812/H [Cagle et al. 1996b]).

Raw Material Selection

While sites in the Camp Pendleton Coastal Zone may vary in age and function, they tend to share a common pattern of lithic raw material frequencies. Volcanic materials (i.e., extrusive, fine-grained igneous rocks like basalt, andesite, and felsite,) dominate lithic assemblages throughout this zone, with percentages ranging between 70-80 percent for most sites. Quartz, which is normally thought of as a low-quality lithic raw material because it tends to flake irregularly, usually makes up 10-25 percent of the debitage, and percentages near or exceeding 30 percent occur only in a few sites in the CPCZ. The relatively high percentage of volcanics and quartz reflects, more or less, the frequency of knappable materials available in alluvial fans and beachside deposits. Almost all of these materials take the form of rounded to subrounded water-worn cobbles. Site SDI-812/H stands out as an exception in this regard, with much lower percentages of volcanic materials in some of the components, especially the Late Prehistoric deposit (e.g., Unit 19). Other lithic raw

materials, including quartzite and obsidian, appear in much lower percentages than the volcanic or quartz materials. Most of the obsidian found in the Camp Pendleton Coastal Zone sites derives from the Coso source area (Byrd et al. 1995, 1996).

One of the most important research topics concerning raw material selection in the Camp Pendleton Coastal Zone is the use of Piedra de Lumbre (PDL) chert, a relatively high-quality lithic raw material that is available in bedrock outcrops about 8 km north-northeast of SDI-811 (Pigniolo 1992). Significant variation in the percentage of PDL chert can be seen in these sites, which ranges from a low of 2.5 percent in SDI-13325 to a high of about 50 percent in Unit 19 of SDI-812/H. While some of the variation in the percentage of PDL chert in individual Camp Pendleton Coastal Zone sites might be due to differences in distance from the PDL source (cf. Renfrew's [1977] "Law of Monotonic Decrement"), the age of the component under consideration also appears to influence the frequency of PDL chert. With the exception of an Early Archaic component found in the lower portion of Unit 5 at SDI-10726, all of the early sites have PDL percentages of less than 3 percent. Late Prehistoric sites, on the other hand, generally have higher percentages of PDL chert, conforming to the temporal trends in the frequency of PDL chert noted by Pigniolo (1992). Nevertheless, something other than site age and distance from source is influencing the frequency of PDL chert in Camp Pendleton Coastal Zone sites. While PDL chert tends to flake more predictably than most of the volcanic or quartzitic materials found in alluvial and beachside deposits, use of this material is hampered by the fact that inclusions in PDL chert tend to limit the size of tools that can be made of this material (Eighmey 1996a).

Techniques of Manufacture

The depth of analysis of the debitage and tools found in Camp Pendleton Coastal Zone sites has varied widely. Consequently, this means that conclusions about the techniques of manufacture utilized and the extent to which different material types were refined has also varied.

Cores are far more numerous than bifaces in the local lithic assemblages, and the production of flakes for use as tools was one of the dominant manufacturing activities undertaken at most of these sites. Bifaces, while present in small percentages in most of the sites, are usually found only in the form of exhausted or broken projectile points or highly refined bifaces. This pattern suggests that projectile points and other bifaces were occasionally maintained at some of these sites, but not manufactured.

More detailed information has been developed regarding the specific techniques used in the production of flake tools from locally available cobbles. The most detailed study comes from the Phase II testing report for SDI-811, -4538, and -10,726 (Byrd et al. 1996). Eighmey (1996b) replicated three cores made on locally available materials, two of which were made using a radial cobble technique, and one of which was made into a biface. Radial cobble reduction involves splitting the cobble in half, and then using the exterior of the cobble as a platform for driving off flakes towards the center of the split face. As this process proceeds, the resulting unidirectional core tends to become conical in shape, with a cortex-covered platform. Use of this technique also creates pieces of debitage with cortical platforms and one or two dorsal ridges that tend to parallel the long axis of the flake, and Eighmey (1996b)

labeled these "Radial Cobble Section Flakes". In his study, Eighmey classified the resulting debitage according to a debitage typology that contained 21 separate morphological types.

When he compared the debitage made of volcanic materials recovered during testing of SDI-811, 4538, and 10726 to his experimentally produced debitage, he found similarities in the frequency of certain flake types. Edge preparation flakes and non-cortical shatter tended to be the most common debitage types in both the experimental and archaeological assemblages. Radial Cobble Section Flakes were found in all of the assemblages, as well as unidirectional cores, indicating that this technique of core reduction had been used at the sites. Bifacial thinning flakes, on the other hand, were found only in the SDI-10726 debitage assemblage.

While unidirectional cores with cortex-covered striking platforms are present in almost all of the sites in the Camp Pendleton Coastal Zone, other core forms are present. Most of the assemblages also contain "polymorphic" cores (*sensu* Byrd et al. 1996) that were worked from a multitude of striking platforms. Similar core reduction techniques were commonly used in areas like the CPCZ, where lithic raw materials are relatively common (Johnson 1989).

A different approach to debitage analysis was taken in Byrd et al. (1995), where the analysts recorded information about specific morphological attributes of the debitage, rather than classifying them according to a typology. In this study of the debitage recovered from sites in the San Onofre/San Mateo area, the lithic analyst categorized the debitage according to condition, the amount of dorsal cortex, the type of cortex, and platform type. Mean debitage size and weight were also reported for some of the assemblages.

Conclusions based on this data regarding the organization of lithic technology in the San Onofre/San Mateo area are few. Byrd et al (1995:113) did note that debitage had been longitudinally split, creating "split platform flakes," which had cortex on their platforms more often than flakes that were categorized as "complete" or "proximal." They suggested that "This difference may be indicative of slightly different reduction methods," but they did not specify what those reduction methods might have been.

Intrasite comparison of techniques of manufacture by material type was also covered in the analysis of debitage from SDI-10728 (Byrd et al. 1997). They found that cortical flakes, which tend to be common in cobble reduction sequences, were most common in the volcanic debitage assemblage. Non-cortical flakes, on the other hand, were most common in the quartz and PDL chert assemblages, and Byrd et al. (1997:66) took this to

> reflect the differing nature of reduction techniques (with cortex being removed from volcanic cobbles throughout the reduction sequence [Eighmey 1996]), and the relative distance from raw materials sources (with the Piedra del Lumbre sample have [sic] virtually no flakes with cortex).

All of these studies have shown that the techniques used to manufacture flaked stone tools tend to be most strongly correlated with material type. As archaeologists have seen in other regions (e.g., Andrefsky 1995), relatively coarse-grained materials tend to be used for the manufacture of relatively unrefined tool forms like choppers or expedient flake tools. More

finely grained materials (e.g., chert), when available, tend to be used for the manufacture of more refined tools like projectile points.

What has not been attempted to any significant degree is the intersite comparison of manufacturing techniques. While some observations suggest that different reduction techniques were used at different sites (see Byrd et al. 1995), there has been little investigation of this idea. In his analysis of the lithic materials from SDI-811, 4538, and 10726, Eighmey (1996a) concluded that there had been little variability from site to site or from period to period in manufacturing techniques, but this seems to clash with the assessment of the debitage from the three sites in the San Onofre/San Mateo area (Byrd et al. 1995). Part of what may be hindering our understanding of differences in manufacturing techniques, if there are any, is the lack of standardization in debitage analysis techniques.

Extent of Refinement

One of the goals of lithic analysis is often to compare the stages of biface manufacture that occurred at different sites in order to understand where different parts of the tool manufacturing process occurred. This information, in turn, can be used to help determine where the site might have fit into prehistoric settlement and subsistence systems. The earliest stages of manufacture are usually seen only in quarry sites, while late stage biface maintenance usually occurs at residential bases or camps. The frequency of manufacturing activities can also be used to separate residential bases from sites that were occupied for shorter periods of time (Binford 1980).

Comparison of sites in the Camp Pendleton Coastal Zone with regard to the stages of biface manufacture would leave one without much data because of the apparent rarity of biface manufacture in these sites. A more fruitful line of investigation would be to compare sites in terms of material types and the degree of core refinement. Those sites that have flaked stone tools and debitage, indicating a wide range of core reduction "stages", were probably occupied for a longer period of time than those with a more narrow range of core reduction "stages." At the same time, the quality of the raw materials being utilized may have had an effect on how much effort was invested in their shaping. As Eighmey (1996a:313-314) suggests, fine-grained materials appear to have been used more intensively than the coarser-grained materials:

> Not surprisingly, the smaller number and size of both fine grained felcite and chert cores within these assemblages suggests that these materials were more intensively used, and it is probably that they were also subjected to more extensive re-cycling. An objective assessment of this hypothesis would involve a very close examination of the dorsal flake scars of the debitage samples from each site.

We will return to this hypothesis later in this chapter when we compare the density of dorsal flake scars on flakes made of relatively fine-grained volcanic rocks to those made of more coarse-grained materials.

Lithics and Livelihood in the Camp Pendleton Coastal Zone

Only a few of the studies mentioned above have explicitly addressed the implications of the flaked stone analyses for conclusions about past lifeways. Faunal remains and shellfish have received the lion's share of the attention, perhaps because they can be easily linked to conclusions about changes in subsistence. Finding the linkages between "lithics and livelihood," as Magne (1985) put it, are more difficult.

The one place in which this has been systematically attempted for the Camp Pendleton Coastal Zone is in Eighmey's (1996a) discussion of the flaked stone assemblages recovered during the testing of SDI-811, 4536, and 10726. He argued that the uniformity through time in the flaked stone tools is probably a response to similarity in tool needs through time, as the groups occupying the project sites were always using marine/littoral resources. At the same time, Eighmey (1996a:315) recognized that the similarity in assemblage through time may also be a response to the fact that "there are only so many ways to reduce a coarse-grained beach cobble."

Eighmey (1996a) also looked beyond the issue of manufacturing techniques to the issue of flaked stone assemblage diversity and its relationship to duration of site occupation and the place of the sites within a broader settlement and subsistence system. Noting the lack of substantial evidence of the manufacture of projectile points and bifaces, Eighmey (1996a:316) proposed that the "manufacture of more elaborate toolkits was clearly taking place elsewhere in their seasonal rounds. In either case, their use was probably largely off-site given the small number of fragments of such tools." This means that we should not take the lithic assemblages in the Camp Pendleton Coastal Zone to be representative of the entire scope of lithic manufacture undertaken by the sites' occupants throughout the year, and that conclusions about the nature of their lifeways based on these assemblages would be incomplete.

Using the diversity of the lithic assemblages as a guide to the role of these littoral sites in prehistoric lifeways, Eighmey (1996a:316) also offered this conclusion:

> Overall the limited number of discarded tools and debitage types strongly suggest that these sites represent short-term occupations concentrated on the exploitation of coastal resources. Given that both the lithic and other artifact assemblages show little change over time, the material remains at these sites may only reflect a very limited portion of prehistoric material culture.

If lithic assemblages were the only lens through which we could view prehistoric settlement and subsistence, this conclusion would probably be regarded with little controversy. The biggest problem comes when we compare the conclusions derived from the analysis of the flaked stone assemblages to the analysis of the vertebrate and invertebrate faunal remains. In their interpretation of the significance of the dense shell middens at SDI-4538, -811, and -10726, Byrd et al. (1996:317) contradict Eighmey's (1996a) assessment of the duration of occupation:

> The sheer quantity of small bean clam shells at each site is quite impressive, with estimates ranging from several million to almost half a billion ... Thus, these sites were not simply short-term collection locations, even if occupied during a single massive *Donax gouldii* resurgence. Instead these shell middens accumulated over considerable periods of time ...

Byrd et al. (1996) may have overestimated the number of *Donax* present in the project sites, especially SDI-811, because they excavated only select portions of the site, which was appropriate for their Phase II investigations. Nevertheless, the large variety of both marine and terrestrial faunal remains found during this Phase III investigation suggest that SDI-811 may have been used repeatedly as a short-term residential center. Potential contradictions between the analysis of the lithic and faunal assemblages recovered during this data recovery excavation will be addressed in the Summary and Integration section (see below).

Information Requirements and Methods

This section covers the "translation" of specific flaked stone artifact attributes into conclusions about duration of occupation and other settlement and subsistence issues. These measures or "translations" should be seen as emerging out of both the theoretical concerns presented in the first section and the previous research covered in the second section. The focus of the flaked stone analysis is on the kinds of tools manufactured at SDI-811 and whether the manufacturing techniques used at this site differed from analytical unit to analytical unit, as well as between sites in the region. Previous analysis has identified utilized flakes, unifacially retouched flake tools, and percussing tools as important in the Camp Pendleton Coastal Zone, and much of this analysis is therefore designed with flake production/core reduction in mind.

Raw Material Identification

The types of stone present in the assemblage from SDI-811 recovered during this data recovery project were studied macroscopically and classified according to the general categories that had been developed in previous reports. These categories included volcanic, quartz, quartzite, undifferentiated chert, Piedra de Lumbre chert, obsidian, granitic, and other.

As noted in the review of previous investigations, volcanic raw materials dominate assemblages in the Camp Pendleton Coastal Zone. To allow for the testing of Eighmey's (1996a) hypothesis about the differential use of fine and coarse-grained materials, artifacts made of volcanic materials were placed into either "volcanic-fine" or "volcanic-coarse" varieties. "Fine-grained" is used here in the archaeological sense, rather than the geological sense, because geologists would probably consider almost all of the volcanics to be "fine-grained." In this study, fine-grained refers to any specimens that were made of crystals that could not be easily distinguished macroscopically. While no attempt was made to actually measure the size of the individual grains, these materials would probably be considered microcrystalline rather than cryptocrystalline (i.e., the size of individual grains probably measured between two and 50 microns). These materials range from black to dark gray to green to purplish in color, and the color varieties cross-cut the grain-size categories. That is,

some of the green, purple, and black-colored materials were fine-grained, while others were coarse-grained. A few of the volcanic materials were porphyrtic, but they were in the minority in the flaked stone assemblage, possibly because of their poor fracture characteristics. In a few cases, it was difficult to decide whether the specimen belonged in the volcanic category or in the "granitic" category. The standard for judgment was that if individual, angular crystals made of a variety of minerals could be recognized macroscopically, then it was classified as a granitic rock. If individual crystals could not be recognized, or if crystals were limited to porphyritic intrusions in an otherwise uniform, fine-grained groundmass, then the specimen was classified as volcanic.

Other difficulties arose when trying to separate quartz from quartzite. Most of the quartz found at SDI-811 appears to be vein quartz, which is macrocrystalline in structure but does not appear in the form of individual, clear quartz crystals. It tends to have a milky white color with only a few recognizable crystal faces. Quartzite, on the other hand, is a metamorphosed arenaceous rock (i.e., a rock consisting of individual pieces of quartz) that has been altered to the point where a new crystalline fabric forms. In the assemblage from SDI-811, much of the quartzite was greyish in color. Some pieces of vein quartz and quartzite were difficult to separate, particularly if the quartzite was on the light end of the color range. Generally, if the rock looked like it was made of cemented sugar grains, it was labeled a quartzite. Any quartz-like rock with macroscopically visible crystal faces was called quartz.

Following Luedtke (1992:5), "*chert* is used as the general term for all sedimentary rocks composed primarily of microcrystalline quartz, including flint, chalcedony, agate, jasper, hornstone, novaculite, and several varieties of semiprecious gems" [italics as in the original]. These rocks were separated from the igneous rocks by virtue of their texture, luster, and other macroscopic characteristics. Many of the items made of chert were assigned to the "undifferentiated chert" category because they did not match the characteristics of any one chert source. An important exception is chert from the Piedra de Lumbre (PDL) chert source, which is located about 8 km north-northeast of the SDI-811 in the upper part of the Piedra de Lumbre drainage. Pigniolo's (1992:57-58) description of the macroscopic description of PDL chert was used to identify any PDL chert in the collection from SDI-811.

Manufacturing Techniques

The variables discussed below were selected to describe variation in debris resulting from the manufacture of flaked stone tools, to examine the nature of the artifacts produced on-site, and the degree to which artifacts were refined in each of the analytical units at SDI-811. The emphasis here will be placed on analyzing core reduction techniques used at different sites and in different analytical units and comparison of "stages" of flake production/core reduction between analytical units and sites. Those sites that have been occupied for a relatively long period of time should contain evidence of a wide range of core reduction activities, both in terms of techniques used and stages of production (i.e., degree of refinement), while those sites that were occupied for shorter periods of time should have a narrower range. In particular, the earliest stages of core manufacture may be absent in those short-term sites where flake tools and cores were imported in a partially refined state after the initial stages had been completed elsewhere.

Two basic kinds of evidence are available to archaeologists trying to reconstruct the nature of the lithic technology used at a site. Discarded objective pieces are probably the best evidence of the manufacturing techniques used. According to Crabtree (1982:43), an objective piece is "Lithic material being worked or formed by various techniques. Can be nodule, flake, blade, preform, core uniface, biface or a permutation of object to completed form." Unfortunately, because the manufacture of flaked stone tools is a reductive process, the exhausted objective pieces found in archaeological sites are often reduced to a form that bears little resemblance to their original forms. Other classes of objective pieces, particularly bifaces, were often transported away from the location of manufacture, making them rare in the archaeological record in a pristine form.

While objective pieces may be the most direct evidence for the nature of the lithic technology used in a site, they are not the most numerous. Debitage, on the other hand, is numerous in the archaeological sites in the study area. It was usually discarded at the location of manufacture as primary refuse or was discarded a short distance away as secondary refuse. The following sections will focus on how one can interpret the technological significance of debitage.

Two approaches to determining the techniques of manufacture leading to the creation of debitage have developed in American archaeology. The first, sometimes called the "typological approach," places pieces of debitage into different technological or morphological types that correspond to specific manufacturing techniques. For example, biface thinning flakes, which usually display longitudinal curvature, multifaceted platforms, multiple dorsal flake scars, and ventral lips, indicate that biface production occurred at a site. The focus of this sort of analysis is the classification of individual pieces of debitage from a site into specific classes or types. The linkage between debitage form and technique of manufacture is built upon the results of replication experiments in which aboriginal techniques are used to create tools identical in form to those found in the archaeological record (Flenniken 1984). An excellent example of this approach is Eighmey's (1996b) analysis of the debitage from the Las Flores Creek and Horno Canyon sites.

The second approach, sometimes called the "non-typological approach" (Ingbar et al. 1989), also replicates debitage using aboriginal techniques. Rather than attempting to classify individual pieces of debitage into classes, this approach measures the attributes of individual pieces of debitage (e.g., weight, the number of dorsal flake scars, and dorsal cortex coverage, etc.) to characterize whole debitage *assemblages*. After the attributes of individual pieces of debitage are recorded, the data from all of the debitage in an assemblage is grouped together and statistically analyzed. The data becomes interpretable through comparison of the archaeological data to data derived from debitage created under controlled experimental conditions.

Many of these studies have used the frequency of debitage in different size classes to determine the nature of the reduction method used. For example, Patterson (1990) size sorted debitage using a series of graduated squares, and then plotted the number of pieces of debitage in each size grade on an XY graph, with the X-axis corresponding to the different size grades and the Y-axis corresponding the number of flakes in each size grade. He found that the data resulting from debitage assemblages created by biface manufacture formed curves that differed from assemblages resulting from the reduction of cores. Bamforth

(1991) used a similar approach, but he focused on debitage width. Ahler's (1989) "mass analysis" used nested screens to size sort debitage, and then statistically compared the frequency of debitage in different size grades and their weights to debitage assemblages created through experimental replication. These approaches are still under development, and some, particularly Patterson's (1990) approach, has been criticized because different reduction techniques sometimes produce the same distributional curves (Shott 1994).

Studies following the "non-typological approach" are not well-developed in the Camp Pendleton Coastal Zone. While there have been analyses that have focused on debitage attributes like the amount of dorsal cortex, flake completeness, and mean size and weight (e.g., Byrd et al. 1995, 1997), this information has not been systematically linked to particular methods of manufacture. At most, researchers have noted that differing percentages of particular attributes in compared sites probably derive from "slightly different reduction methods" (Byrd et al. 1995:115), but what those methods might be has not been identified.

It was hoped originally that this analysis might combine aspects of both approaches, using conclusions derived from one approach to be checked against the other. Eighmey's (1996b) debitage typology was developed during the analysis of debitage from earlier work at SDI-811, and it would be well suited to this combination approach. Unfortunately, it is impossible to duplicate Eighmey's (1996b) types with any level of certainty based on the descriptions provided in the text. The subjectivity inherent in the typological approach is its weakness (Connolly and Musil 1994), and because of this concern about lack of replicability, Eighmey's types were not used in this analysis.

One of the goals of the lithic analysis was to develop data that could be compared to data from previous projects. The research undertaken at SDI-812/H, which is also in the Los Flores/Horno Canyon area, concentrated on specific debitage attributes, especially thickness and the presence/absence of dorsal cortex (Cagle et al. 1996b). Taking a wider view, debitage analysis in the San Mateo/San Onofre Creeks area took a non-typological approach, relying on debitage size, completeness, dorsal cortex amount, cortex type, and platform type to characterize the assemblages (Byrd et al. 1995). To allow for comparisons with previously developed datasets, these attributes were incorporated into the present debitage analysis when possible.

Degree of Refinement

Approaches to the determination of "stage" or the degree of refinement represented in debitage assemblages may be divided along the same lines as the approaches to understanding techniques of manufacture. For example, after it has been determined that biface manufacture was undertaken in a series of sites, analysts following the "typological approach" often compare the number of "early biface thinning flakes" to the number of "pressure flakes" and other types of flakes to determine where the early and stages of biface production were occurring (e.g., Jones et al. 1994). The limitations of studying biface stage in the Camp Pendleton Coastal Zone have already been discussed, but one could conceivably apply Eighmey's (1996b) debitage typology to a similar task. For instance, those sites or analytical units that contained a relatively large number of "cobble sectioning flakes," which derive from initial attempts to drive flakes off of a rounded cobble, would be considered to be earlier in stage than those that contained a relatively large number of "longitudinal,

unidirectional reduction flakes off modified platform core (non-cortical) flakes," which only appear after a core has been modified and much of the cortex has been removed. Nevertheless, assessing the degree of refinement using this method is subject to the same limitations as any typological approach.

Good progress has been made in comparing the degree of refinement using non-typological approaches. For example, Ingbar et al. (1989) found that they could predict when a flake had been removed from an objective piece in a sequence of flake removals by measuring the length, width, thickness, and number of dorsal flake scars of that flake. When combined with the data from other flakes, they were able to distinguish those debitage assemblages that resulted from earlier stages of manufacture from those assemblages resulting from later stages of manufacture. Others have used the frequency of debitage with cortex on their platforms or dorsal surfaces to assess stage or the degree to which objective pieces were refined. As Bamforth (1991:190) notes, "Later stages of manufacture produce fewer flakes with cortex on their platforms or dorsal surfaces." Although Bamforth (1991) was addressing stages of biface manufacture, the same should be true of debitage resulting from core reduction sequences. When interpreting the "stage" of debitage assemblages based on the frequency of debitage with dorsal cortex, one should remember that cortex may be present on debitage removed from volcanic cobbles at any point in the production sequence (Eighmey 1996b). Nevertheless, the frequency of debitage with dorsal cortex should decrease as the cores being worked become more refined.

Definitions

The following discussion will present the artifact typology used to classify the flaked stone artifacts recovered from the data recovery investigations at SDI-811. In addition, this discussion will specify what role the collected data played in the lithic analysis.

The project collection was divided for analysis into two main categories: worked lithics and debitage. *Debitage* is defined as "residual lithic material resulting from tool manufacture" (Crabtree 1982:32), and it includes both unmodified flakes ("any object showing a clear ventral flake surface, whether or not a striking platform is present" [Bamforth 1991:190]) and shatter. *Worked lithics* include all objects from which flakes appear to have been removed, regardless of whether or not that was done intentionally by the prehistoric knapper or unintentionally by post-depositional processes. Determining whether the modifications seen in a particular worked lithic are intentional or unintentional is difficult using the macroscopic techniques available in this project, and it becomes most crucial when one is trying to separate debitage from utilized flakes from flakes that were modified by post-depositional processes.

In this study, any piece of debitage that showed some evidence of a modified edge, regardless of agency, was considered either a modified flake or a flake tool. *Modified flakes* were separated from *flake tools* on the basis of the length of the flake scars that extend inward from the edge of the piece. Those pieces that have flake scars that extend less than 2 mm were considered modified flakes, while those that extend more than 2 mm were considered flake tools. While this cutoff point is arbitrary, it has the benefit of being an explicit standard, and it has been used in previous studies of flake tools (Barton 1988). Flake tool, as

the category is used here, is synonymous with ASM's "unifacially retouched flake" category, while modified flake is synonymous with ASM's "utilized flake" (see Byrd et al. 1996).

Three other categories of worked lithic were defined. Following the practice established in other analyses of lithics in the Camp Pendleton Coastal Zone, *bifacially retouched pieces* were any worked lithics that were bifacially worked over the majority of their surfaces. (No bifacially retouched pieces were identified in the assemblage recovered during this data recovery investigation, which mimics the results of the earlier testing project [Byrd et al. 1996].) These were distinguished from *cores*, which were those items that did not appear to be used for any function other than acting as a source for flakes. The final category of worked lithic was *percussing tools*, which included hammerstones, choppers, and knapping stones.

Procedures and Variables for Debitage Analysis

The general approach taken for this debitage analysis is to draw inferences about stone tool production from an assemblage rather than individual artifacts. The emphasis is therefore on describing the characteristics of the flakes and looking for patterns in these characteristics rather than on classifying flakes into categories (such as "biface thinning flake" or "core rejuvenation flake") which rely on a priori technological inferences (Sullivan and Rozen 1985). Variables were therefore selected for this analysis to allow for intersite comparisons, particularly with those sites excavated by ASM in the Camp Pendleton Coastal Zone, and to provide multiple independent lines of evidence relevant to the issues being studied.

Seven variables, including raw material type, were recorded for those pieces of debitage that did not pass through 1/4" screens used during water-screening, and those variables are described in the paragraphs below. Some of the excavated fill was screened through 1/8" or 1/16" mesh, and the debitage recovered in these small-mesh screens were sorted by material type, and then counted and weighed as a group by unit and level (see Appendix A). All debitage, regardless of screen size or material type, were included in the summaries of raw material percentages. While some lithic analysts include those flakes that pass through 1/4" mesh in the more detailed phases of their studies (e.g., Ahler 1989), recent work has shown that it is often possible to identify method of manufacture and degree of refinement without having to analyze the smaller material. For example, Ingbar et al. (1989) successfully identified different stages of biface production in an assemblage using just the 1/4" fraction – analysis of the small debitage was not necessary. Second, the relatively coarse grain size of volcanic rock and quartzite make it difficult to recognize important flake characteristics on pieces that pass through 1/4" mesh because the graininess of the stone distorts or obscures many of the small scale features needed for analysis. For example, it is difficult to determine if the platform surface on a small coarse-grained volcanic flake was truly multifaceted or just appeared that way because the texture of the piece created the illusion of facets. Ridges, platforms, and other important flake characteristics are most reliably identified on pieces larger than 1/4" mesh (Bamforth 1991).

Completeness. Each piece of debitage was coded as complete (C), proximal (P), distal (D), split platform (S), and other (O), following the categories set out in Byrd et al. (1995). Completeness has sometimes been used to argue for particular stages of manufacture. For example, it is commonly thought that incomplete flakes (i.e., shatter) are most common in

the early stages of reduction sequences (Sullivan and Rozen 1985), but this approach has been criticized (Amick and Mauldin 1989; Ensor and Roemer 1989). Nonetheless, it is an effective way of providing basic descriptive data about the characteristics of the flake and its degree of fragmentation. Split platforms are also indicative of bipolar reduction or wedging initiations (Cotterell and Kamminga 1987). The "Other" category is reserved for those pieces of debitage in which one cannot reliably tell if the piece is complete or not. This category also includes "shatter."

Platform Type. Platform type was the second debitage attribute covered in Byrd et al. 1995, and it is included here to provide for intersite comparisons. Each piece of debitage was coded as cortical (C), crushed (CR), single faceted (S), multifaceted (M), split (L), split and cortical (LC), abraded (B), none (N), and other (O). This attribute can be used to inform us about both the techniques of manufacture used and degree of refinement. As reduction of an objective piece proceeds, debitage with cortical platforms should give way to debitage with single faceted platforms, and then multifaceted platforms. Split platforms are indicative of a particular manufacturing technique, bipolar reduction, while abraded platforms indicate that some effort was spent in shaping platforms prior to the removal of a flake. Multifaceted platforms can occur as the result of almost any manufacturing technique, but they are particularly common in biface production. "Other" is reserved for those cases in which a platform may be present, but it cannot be easily identified.

Dorsal Cortex Class. Different but comparable means of recording the amount of dorsal cortex on debitage have been used in the ASM report of sites in the San Onofre/San Mateo area (Byrd et al. 1995), the testing report for SDI-10726 (Byrd et al. 1997), and the excavations at SDI-812/H (Cagle et al. 1996b). The definitions used here do not exactly match any of the previous reports, but they will allow for intersite comparison. A piece of debitage was coded as a *decortication* flake if 100 percent of its dorsal surface was covered with cortex, a *primary* flake if 99-75 percent of its dorsal surface was cortex covered, *secondary* if the dorsal surface was 74-1 percent cortex covered, and *tertiary* if the flake did not have any dorsal cortex.

Dorsal cortex class is best used as an indicator of the stage of production. As objective pieces are progressively refined, they tend to produce debitage with less and less dorsal cortex, assuming that the objective pieces had cortex on them in the first place. In the study area, where many of the objective pieces appear to have been water-worn cobbles, this is probably a safe assumption. Chert objective pieces from bedrock outcrops (i.e., PDL chert) may not have had any cortex even in their earliest stages, so caution was used in the comparison of chert artifacts from different sites or analytical units.

Maximum Width. Width was measured to the nearest 0.1 mm as the greatest distance between lateral flake margins along an axis perpendicular to the axis of applied force. With the exception of debitage analysis from SDI-812/H (personal communication, Woodman 1997), the width of debitage has not been reported for other sites in the Camp Pendleton Coastal Zone. Nevertheless, this attribute has been used in a number of other analyses (Bamforth 1991; Hess et al. 1997), allowing the data from SDI-811 to be compared to sites in other areas that have a wider range of lithic raw materials available.

The width of debitage in an assemblage can inform us about techniques of manufacture. Using quantile plots of debitage width, one can determine the likely technique of manufacture by the slope of the plotted points. Debitage assemblages derived from the reduction of cores tends to produce quantile plots of debitage width with relatively flat slopes, while plots based on debitage assemblages produced from the manufacture of bifaces tends to produce more nearly vertical slopes.

Weight. Weight was measured to the nearest 0.1 g using an electronic scale. Mean weight of debitage was reported for two sites in Byrd et al. (1995), but most of the other reports from the Camp Pendleton Coastal Zone have not reported on this attribute. Weight is a good measure of the stage of production. As the size of objective pieces decreases with progressive reduction, the weight of the resultant debitage also declines. Assemblages that have small average weights should be seen as being later in stage than assemblages with high average weights, assuming that one has controlled for differences in raw material type (Odell 1989).

Dorsal Scar Count. The number of flake scars greater than 2 mm in length on the dorsal surface of all pieces of debitage was recorded. Flakes classified as decortication flakes received a dorsal scar count value of zero, and flakes that had no arrises on the dorsal surface were given a dorsal scar count value of one. The minimum length of 2 mm was established to help separate incidental flake removals from larger, more important, flake removals.

Dorsal scar count, in and of itself, has a checkered history in reconstructing degree of refinement or stages of production. While some early experimenters found a good relationship between stage and the number of dorsal flake scars (Magne and Pokotylo 1981), later studies have not born this out (Connolly and Musil 1994; Ingbar et al. 1989). Nevertheless, Ingbar et al. (1989) found that dorsal scar count, when combined with other measures of debitage size to form *dorsal scar density* (i.e., dorsal scar count/flake length x width), was effective in characterizing the stage of debitage assemblages. That is, as the objective piece became more refined or more time was invested in shaping it, the debitage resulting from it tended to have a higher dorsal scar density. Tomka (1989) has also used dorsal scar count in combination with debitage size to distinguish amorphous core reduction from biface production.

In this analysis, dorsal scar count was divided by debitage weight, another measure of debitage size that is well correlated with debitage area (Hess 1997), to arrive at dorsal scar density. Dorsal scar density (i.e. dorsal scars/gram) is usually rightward skewed in the distribution of its values (i.e., there are many more small values than large values), making it necessary to log-transform the data using the natural logarithm (log base *e*) to give it a more normal distribution (Shennan 1990). To avoid the problem of computing the log of 0, which is impossible, the minimum non-zero dorsal scar count per gram value from this collection (0.017 scars/gram) was added to all of the cases prior to log-transformation. This information was used specifically to address the hypothesis forwarded by Eighmey (1996a) regarding differences in fine and coarse-grained materials in the extent of refinement.

Procedures and Variables for Worked Lithics

All worked lithics, regardless of their location in the site relative to the five defined analytical units, were analyzed. The goals of this analysis were to determine the range of manufacturing techniques used in their creation and to see how the extent of energy investment in tool form varied from one site to the next and from one analytical unit to the next. In the case of the tools, a combination of typological and non-typological approaches was used. A typological approach was appropriate in this case because artifact classes developed in previous studies (Byrd et al. 1995, 1997; Eighmey 1996b) could be duplicated reliably and they effectively communicated something about the variations in manufacturing technique. The nontypological analysis concentrated on the collection of attribute-based data that would provide more detailed information about differences in the extent of refinement or curation.

Core Analysis. The raw material type of the cores was recorded as described in the Raw Material Identification section (see above). They were then classified according to the number of striking platforms event. Cores with a single striking platform from which all flakes were driven in the same direction were classified as *unidirectional*. Cores that had two striking platforms were labeled *bidirectional*, while those that took the form of large bifaces were categorized as *bifacial* cores (no bidirectional or bifacial cores were identified in the assemblage recovered during this data recovery investigation). Those cores that had multiple striking platforms were classified as *polymorphic* or *amorphous* cores. Cores that could not be placed into any of these categories were put into the *other* category. Categorization of the cores according to type allowed the comparison of manufacturing techniques between and within sites.

Other formal attributes that were recorded included *completeness* (complete or fragmentary), *cortex type* (water-worn, bedrock, none, or other), and the core's basic *dimensions* (length, width, thickness, and weight). Those cores that were used relatively more extensively than others should be both smaller and more fragmentary. Therefore, these attributes helped us to understand extent of refinement.

Utilized Flake Analysis. Analysis of the utilized (aka modified) flakes closely followed the procedures for debitage analysis. In addition to *all of the characteristics recorded for the debitage*, the *length* and *thickness* of the utilized flakes were recorded. A simple count of the *number of modified edges* was also recorded. Recording the same attributes as the debitage allowed comparisons between the utilized flake assemblage and the debitage assemblage, and recording of the dimensional attributes allowed one to assess the extent to which the tools were refined prior to their discard.

Flake Tool Analysis. Attributes recorded for the flake tools included completeness (complete vs. fragmentary), dorsal cortex coverage (as defined for the debitage), as well as basic dimensional data (length, width, thickness, and weight).

Special attention was given to assessing how much effort was spent on refining the flake tools. Kuhn (1990) developed an index of flake tool reduction or "used-upedness" that compares the thickness of the worked edge to the maximum thickness of the piece. Reasoning that the thickness of the worked edge (*t*) approaches the maximum thickness (*T*)

as the flake tool is reworked, Kuhn (1990) found that *t/T* ranged from 0.0 to 1.0, with *t/T* increasing as the flake tool was reworked repeatedly.

Given that it is sometimes difficult to accurately measure *t*, Kuhn (1990) devised a formula for the computation of *t/T* based on the extent to which retouch scars invade the face of the tool and the angle of the retouch scars:

$$\text{Kuhn's } t/T = \frac{\sin(a)E}{T}$$

where a = the angle of the retouch scars, E = the extent of retouch scars measured in millimeters, and T = the maximum thickness of the artifact. Kuhn's *t/T* index was computed for each worked edge on a flake tool, up to a maximum of four edges. In the case of this assemblage, the maximum number of worked edges was two. Values less than 0.5 are typical of expedient flake tools used only a few times, while higher values are usually associated with more highly curated tools.

Percussing Tool Analysis. The percussing tools were classified according to subtype (hammerstones, choppers, knapping stones, and other), and raw material type. The completeness of the tool was recorded, and measurements were taken on length, width, thickness, and weight.

In most cases, the items that were categorized as percussing tool in this report matched those used by ASM. Nevertheless, some of the artifacts that they may have classified as percussing tools may have been classified as utilized flakes in this study.

Tool Use

While understanding the range of manufacturing techniques used and the variations in the degree to which objective pieces were refined can be useful in reconstructing the place of a site in larger settlement systems, this information does little to help us understand the specific activities that occurred at a site other than those involving the manufacture or modification of flaked stone tools. Use-wear studies of flaked stone tools have attempted to provide information about subsistence-related activities, and these studies usually come in one of three types. Some studies of use-wear rely exclusively on macroscopically visible indications of flake tool use, including "microfractures, rounding, abrasion, striations, and polish (generic)" (Byrd et al. 1996:185). The second group of analysts have made use of low-power magnification to characterize use-wear (i.e., less than 200x magnification), while the third have made use of higher magnification levels (greater than 200x).

Use-wear analysis at any level of magnification is a controversial topic, with some researchers advocating low-power magnification, while others advocate exclusively high power magnification (see Grace [1996] for a recent review of use-wear studies). Almost all

archaeologists regard macroscopic studies of use-wear as suspect because of the multiple agencies that can create edge damage (Flenniken and Haggarty 1979).

Regardless of where one stands on the issue of what type of use-wear analysis is best, a larger issue looms over use-wear analysis at SDI-811. Are use-wear studies applicable to coarse-grained materials like basalt, quartz, and quartzite that make up the majority of the flaked stone artifacts in this collection?

Assuming for the moment that high-power magnification use-wear studies are more reliable than low power studies (see Bamforth et al. [1990]), one would need to determine whether or not diagnostic polishes form on coarse-grained materials. A pilot study by Sussman (1985) using high-power magnification to study microwear traces on quartz crystals was encouraging, but she does not appear to have pursued this research further. Nevertheless, this study is of little use to the analysis of the quartz artifacts from SDI-811 because most of them are made of vein quartz that does not form discrete edges like quartz crystal. No published studies providing for the high-power analysis of volcanic rocks like basalt were found in the archaeological literature. Based on a series of unpublished experiments, it appears doubtful that diagnostic use-wear polishes form on at least some basaltic materials (personal communication, Woodman 1997).

Another means of assessing the function of flaked stone tools has been blood residue analysis. Initial studies showed that blood residues on artifacts in archaeological sites could be identified reliably, but subsequent studies have cast significant doubt on these tests (Fiedel 1996). Because of these concerns, no blood residue analysis was attempted with any of these flaked stone artifacts.

In light of this review, use-wear analysis was limited to macroscopic assessment. While microwear assessments could have been attempted for the chert artifacts, the number of chert artifacts was so low that any conclusions about the frequency of particular tasks would have been statistically suspect. Furthermore, Bamforth (1991) found that use-wear traces were usually absent on any artifacts measuring less than 25 mm long, excluding most of the chert in this collection. In lieu of any reliable means of assessing microscopic use-wear, any macroscopically visible use-wear was recorded in a "comment" field during the collection of other data about the form of the artifacts.

Quantitative and Statistical Issues

When considering the reliability of statistical analyses of assemblages, large sample sizes are preferable over small sample sizes. Because of the cost attendant with the analysis of large samples, though, archaeologists often seek to minimize the number of artifacts that they analyze, setting up a possible conflict between sample adequacy and feasibility. Usually this conflict is resolved by selecting a sample that contains the minimum number of items for reliable analysis, but no more. While the minimum number of samples needed in order to achieve certain levels of precision can be determined using statistical formulae (Shennan 1990), archaeologists often fall back on the "100 items in a sample" rule of thumb (e.g., Ames 1988). That is, all things being equal, one can generally trust the results of a statistical analysis if it is based on 100 items.

For many of the sites in the Camp Pendleton Coastal Zone, the total number of worked lithics recovered from the sites is far less than 100 items, meaning that intersite comparisons based on these items may be somewhat suspect. This is certainly the case for this data recovery excavation in SDI-811, where only 64 worked lithics were recovered from the entire site. Most of the debitage analyses, on the other hand, are based on more than 100 items per site, meaning that their reliability is more secure.

One of the goals of this lithic analysis was to compare the debitage found in each of the analytical units, meaning that the debitage samples from each of these analytical units would have to be sufficiently large for reliable analysis. As much as possible, approximately 100 pieces of debitage from each of the analytical units (please refer to Chapter 5 for details about each of the analytical units) were selected for analysis to ensure that any statistical conclusions were based on an adequate sample. The relatively low density of the debitage in the lower component of Unit 109 (i.e., AU 3) made it impossible for this analytical unit to fulfill the 100 item rule. Therefore, any conclusions concerning this analytical unit are considered tentative. Only the coarse-grained volcanic debitage was frequent enough for reliable comparisons between analytical units (Table 6-1).

Table 6-1. Count of Analyzed ¼" Debitage from the Analytical Units (AUs)

Material	*AU 1 (Units 100 & 122)*	*AU 2 (Unit 109 Upper)*	*AU 3 (Unit 109 Lower)*	*AU 4 (FAR I)*	*AU 5 (FAR II)*	*Outside of AUs*	*Total*
Chert, undiff.[a]	1	1	1	1	1	5	10
Granitic	1	4	-	-	2	-	7
PDL Chert[a]	2	-	-	3	-	6	11
Coarse Volcanic	91	89	24	92	92	-	388
Fine Volcanic	5	8	4	14	7	30	68
Quartzite	3	5	3	12	5	-	28
Total	103	107	32	122	107	41	512

[a] Includes both 1/4" and 1/8" debitage.

The chert, quartzite, and fine-grained volcanic debitage received unique treatment during the technological analysis. All pieces of chert from throughout the site, both inside and outside the defined analytical units and from 1/8" and 1/4" screens, were analyzed because of their rarity. The quartz flakes were excluded from the technological analysis because their nonconcoidal fracture characteristics make it difficult to identify pertinent flake characteristics. Analysis of the debitage in the five analytical units did not result in enough data on pieces of fine-grained volcanic debitage for reliable statistical comparison to the coarse-grained material, so 40 additional flakes of this material type from outside the analytical units were examined.

An important part of the statistical comparison of materials from different analytical units is assessment of the significance of any differences between them. When comparing analytical units using nominal-level data (e.g., the number of pieces of debitage in each of the raw material types), X^2 tests were often used, although the low frequency of certain material types makes some of these significance tests suspect. In the case of normally-distributed ratio or interval level data (e.g., log-transformed dorsal scar density), Student's t-test (Shennan 1990) was used. All significance tests were conducted at the 95 percent confidence level.

Assemblage Content

A total of over 3,000 flaked stone artifacts were recovered as a part of these excavations (Table 6-2).

Table 6-2. Frequency of Flaked Stone Artifacts by Excavation Unit

Unit	*Debitage*[a]	*Cores*	*Utilized Flake*	*Unifacially RetouchedTool*	*Percussing Tool*	*Total*
100	101	1	-	1	-	103
101	24	-	-	1	-	25
102	10	-	-	-	-	10
103	57	-	-	1	-	58
104	133	-	1	-	-	134
105	23	-	-	-	1	24
106	7	-	-	-	-	7
107	325	1	-	-	-	326
108	154	-	-	-	-	154
109	257	1	2	1	2	263
110	62	-	2	1	-	65
111	18	1	-	-	-	19
112	4	-	-	-	-	4
113	182	3	-	-	-	185
114	285	3	3	1	1	293
115	371	3	1	-	-	375
116	227	6	2	-	1	236
117	186	-	-	2	-	188
118	70	-	1	-	-	71
119	69	1	-	-	-	70
120	82	1	1	-	-	84
121	281	-	1	2	-	284
122	109	1	-	-	-	110
123	33	-	-	-	-	33
AUG-115	4	-	-	-	-	4
CS-101	3	-	-	-	-	3
CS-102	7	-	-	-	-	7
CS-103	4	-	-	-	-	4
CS-106	1	-	-	-	-	1
CS-108	21	-	-	-	-	21
CS-109	58	-	-	-	-	58
CS-110	2	-	-	-	-	2
CS-115	36	-	-	-	-	36
CS-116	17	2	-	-	-	19
CS-121	17	-	-	-	-	17
CS-122	3	-	-	-	-	3
CS-123	4	-	-	-	-	4
Surface	0	2	3	2	4	11
Total	3,247	26	17	12	9	3,311

a This table includes all debitage recovered from the excavation units, regardless of material type or size. See the Quantitative and Statistical Issues section for more details about the sample of analyzed debitage.

This section provides basic descriptive details about those artifacts as a preparation for the analyses reported in the following Technological Analysis, as well as a discussion of Assemblage Diversity. For more detailed data about individual artifacts, please consult the lithic data tables in Appendix F.

Debitage

Debitage was the single most common class of flaked stone artifact found in SDI-811, making up just over 98 percent of the assemblage. Volcanic debitage constituted just over 68 percent of all of the debitage, with quartz and quartzite debitage coming in a distant second and third. While the percentages of volcanic debitage varied somewhat from analytical unit to analytical unit (Table 6-3), the ranking by frequency always followed the same pattern.

Table 6-3. Distribution of Debitage Material Types by Analytical Unit

AU	*Volcanic*	*Quartz*	*Quartzite*	*Chert*	*Granitic*	*Metamorphic*	*Count*
1	70.1%	24.8%	2.2%	1.5%	1.5%	0.0%	137
2	81.5%	10.1%	4.2%	0.8%	3.4%	0.0%	119
3	65.1%	25.6%	7.0%	2.3%	0.0%	0.0%	43
4	66.4%	24.3%	7.9%	0.7%	0.7%	0.0%	153
5	59.3%	35.9%	3.0%	0.6%	1.2%	0.0%	167
Outside AUs	68.9%	26.0%	3.0%	0.6%	1.4%	0.1%	2,628
Total	68.5%	26.0%	3.3%	0.6%	1.4%	0.1%	3,247

Cores

The assemblage of 26 cores, which made up less than 1 percent of the total flaked stone assemblage, consists of three types: unidirectional, polymorphic, and other. Polymorphic cores were the most numerous type, with the remainder evenly split between unidirectional and undifferentiated forms (Table 6-4). Three of the cores that were placed into the "other" category (Catalog # 371 from Unit 107, Catalog # 520 from Unit 114 [AU 4], and Catalog # 586 from Unit 116 [AU 5]) had wedge-shaped cross sections, which is suggestive of bipolar core reduction.

Table 6-4. Distribution of Core Types by Analytical Unit

	UNIDIRECTIONAL		POLYMORPHIC		OTHER		TOTAL	
AU	*ct*	*%*	*ct*	*%*	*ct*	*%*	*ct*	*%*
1	1	100	-	-	-	-	1	100
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	2	25	4	50	2	25	8	100
5	-	-	-	-	3	100	3	100
Outside AUs	3	21	9	64	2	14	14	100
Total	6	23	13	50	7	27	26	100

The analytical units showed some variation in the frequency of core forms, with AU 1 producing exclusively unidirectional forms, while AU 5 produced only "other" forms. The broadest range of core types appeared in AU 4. While the majority of the cores were clearly from outside of the defined AUs, AU 4 (FAR I) alone produced over 30 percent of the total number of recovered cores, far more than any of the other analytical units. No cores were recovered from either AU 2 or AU3.

Utilized Flakes

Utilized or modified flakes made up only 0.5 percent of the total flaked stone assemblage (n = 17), but they showed strong spatial patterning. Two of the analytical units (AU 1 and AU 3) did not produce any utilized flakes, while they were fairly common in AU 4 (Table 6-5). Almost all were made out of volcanic materials except for a small, modified chert flake from AU 2 and an utilized quartz flake from outside of the AUs. Almost all of these tools showed evidence of modification along one edge only, with the exception of a single tool from AU 4 (Catalog # 470), which had two utilized edges. Some of these tools (e.g., Catalog # 406) had heavily rounded edges, but the majority showed utilization only in the form of small flakes removed from one of the flake margins.

Table 6-5. Distribution of Utilized Flakes by Analytical Unit

AU	*Volcanic*	*Quartz*	*Chert*	*Total*
1	-	-	-	-
2	-	-	1	1
3	-	-	-	-
4	4	-	-	4
5	2	-	-	2
Outside AUs	9	1	-	10
Total	15	1	1	17

Flake Tools (Unifacially Retouched Flakes)

The 12 flake tools recovered during the data recovery excavations were broken down into two categories based on the Kuhn's *t/T* values for the worked edges. Those flake tools that had a Kuhn's *t/T* value greater than 0.5 on at least one worked edge were classified as *formal flake tools*, while those that had Kuhn's *t/T* values less than 0.5 were classified as *informal flake tools*. As Table 6-6 shows, the majority of the flake tools would be considered informal by these criteria. The formal flake tool from AU 1 (Catalog # 394) was unique in form; the flat or "ventral" surface of the flake tool was cortex-covered, indicating that it was actually the exterior of a water-worn cobble. It resembled a unidirectional core that had been worked using the radial cobble reduction technique, and then was "flipped over" and used as a flake tool. The other formal flake tool (Catalog # 323), which was from Unit 109 just below AU 2, was made on a porphyritic but glassy volcanic material.

Table 6-6. Distribution of Flake Tools (Unifacially Retouched Tools) by Analytical Unit

	FORMAL		INFORMAL		TOTAL	
AU	*ct*	*%*	*ct*	*%*	*ct*	*%*
1	1	100	-	-	1	100
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	1	100	1	100
5	-	-	1	100	1	100
Outside AUs	1	11	8	89	9	100
Total	2	17	10	83	12	100

Percussing Tools

Percussing tools were the most rare of the flaked stone artifacts recovered from SDI-811. Of the nine recovered, only three were found in one of the defined analytical units (Table 6-7). When viewed as a whole, the numbers of choppers and hammerstones were fairly well balanced. With the exception of a quartz hammerstone and a quartz chopper found on the surface of the site, all of the percussing tools were made of water-worn volcanic cobbles. One of the percussing tools (Catalog # 715 from the surface of the site) was a fragment of a volcanic cobble with a small pecked area about 20 mm in diameter that may have been used as an anvil stone for bipolar reduction.

Table 6-7. Distribution of Percussing Tools by Analytical Unit

	CHOPPER		HAMMERSTONE		TOTAL	
AU	*ct*	*%*	*ct*	*%*	*ct*	*%*
1	-	-	-	-	-	-
2	-	-	1	100	1	100
3	-	-	-	-	-	-
4	-	-	1	100	1	100
5	1	100	-	-	1	100
Outside AUs	4	67	2	33	6	100
Total	5	56	4	44	9	100

Technological Analysis

While the lithics data from the data recovery excavations at SDI-811 are the heart of this analysis, data from seven other sites were incorporated for comparison (Table 6-8). These sites represent a range of time periods and functional types, and they will act as a baseline to which the data from SDI-811 may be compared. For example, if SDI-811 was a large village site, we would expect that the flaked stone assemblage would more closely resemble the assemblage from SDI-13325 than SDI-4411. Some comparisons will also be made between

the earlier test excavations at SDI-811 conducted by ASM and the current data recovery investigations.

Table 6-8. Data from Other Sites Incorporated into this Analysis for Comparison to CA-SDI-811

Site No.	*Age*	*Site Type*	*Data Used*	*Reference*
SDI-1074	Late Prehistoric	Base camp	A, B, C, D, E, F	Byrd et al. 1995
SDI-4411	Late Prehistoric	Short term camp	A, B, C, D, F	Byrd et al. 1995
SDI-13325	Archaic to initial Late Prehistoric	Residential	A, B, D, E, F	Byrd et al. 1995
SDI-10728, Locus A	Early Archaic & Late Prehistoric	Base camp or residential	*A, E, F	Byrd et al. 1997
SDI-10728, Locus B	Late Prehistoric	Short term camp	*A, E, F	Byrd et al. 1997
SDI-4538	Late Prehistoric	Base camp	A, F	Byrd et al. 1996
SDI-10726, Locus A	Late Prehistoric	Short-term camp	A, F	Byrd et al. 1996
SDI-10726, Locus B (upper)	Late Prehistoric	Base camp	A, F	Byrd et al. 1996
SDI-10726, Locus B (lower)	Early Archaic	Base camp	A, F	Byrd et al. 1996
SDI-812/H	Late Prehistoric & Ethnohistoric	Residential	A, B, E, G	SAIC, unpublished data
SDI-811, Phase II testing	Archaic to Late Prehistoric	Base camp or residential	A, F	Byrd et al. 1996

A = debitage raw material percentages
B = debitage condition/completeness
C = mean weight
D = debitage platform characteristics
E = debitage dorsal cortex classes
F = frequency of tool types
G = debitage width
* = data available for the whole site, but not individual components

Raw Material Selection

As Table 6-9 shows, the occupants of SDI-811 made use of the entire range of materials available to them on-site or nearby, including granitic rocks, undifferentiated metamorphic rocks, quartz, quartzite, and volcanics. The only materials that probably came from off-site were the few pieces of chert.

As seen in the other sites in the Camp Pendleton Coastal Zone, the three most common material types at SDI-811 (in order of their frequency) are volcanics, quartz, and quartzite. With the exception of two artifacts (a modified piece of chert from AU 2 [Catalog # 331] and a lightly retouched granite cobble sectioning flake from Unit 110 [Catalog # 647]), all of the flaked stone tools recovered during these data recovery excavations were made of the three most frequent material types. This pattern strongly suggests that almost all of the tools found on-site were made on-site, rather than having been imported from elsewhere in a semi-refined state.

Table 6-9. Frequencies of Flaked Stone Artifacts by Class and Material Type, CA-SDI-811 Data Recovery Excavations[a]

	Debitage		Core		Utilized Flake		Unifacially Retouched Tool		Percussing Tool		Total	
Material	*ct*	*%*	*ct*	*%*	*ct*	*%*	*ct*	*%*	*ct*	*%*	*ct*	*%*
Chert	21	0.6	–	–	1	5.9	–	–	–	–	22	0.7
Granitic	46	1.4	–	–	–	–	1	8.3	–	–	47	1.4
Metamorphic	2	0.1	–	–	–	–	–	–	–	–	2	0.1
Quartz	845	26.0	4	15.4	1	5.9	–	–	2	22.2	852	25.7
Quartzite	108	3.3	3	11.5	–	–	–	–	–	–	111	3.4
Volcanic	2,225	68.5	19	73.1	15	88.2	11	91.7	7	77.8	2,277	68.8
Total	3,247	100.0	26	100.0	17	100.0	12	100.0	9	100.0	3,311	100.0
% of Whole Assemblage	–	98.0	–	0.8	–	0.5	–	0.4	–	0.3	–	100.0

[a] This table includes all flaked stone artifacts, regardless of material type or screen size.

Turning to the debitage, we again see that volcanic, quartz, and quartzite were the three most common material types (Table 6-10). For the most part, the percentages of these materials are similar to the results of the prior test excavations at SDI-811 (Byrd et al. 1996), as well as other sites in the Camp Pendleton Coastal Zone. The only spatial trend in the percentage of different material types is that those sites in the San Onofre/San Mateo area have a slightly higher percentage of quartzite debitage than most of the other sites in the Camp Pendleton Coastal Zone. This spatial trend in quartzite frequencies probably has more to do with geological factors than cultural ones (i.e., more quartzite may be available in the San Onofre/San Mateo area, so it was used more frequently). Even so, quartzite was more frequent in the SDI-811 data recovery assemblage than any of the other assemblages in this area.

While spatial trends in the frequency of material types may be somewhat weak, the same cannot be said for temporal trends in the frequency of PDL chert. Previous researchers have found that PDL chert tends to be most frequent in terminal Late Prehistoric sites, and the debitage from SDI-811 follows the same pattern.

The latest analytical unit, AU 1, which dates to about cal A.D. 800, has the highest percentage of PDL chert of any of the analytical units. Some caution, though, should be exercised when interpreting this percentage because it is based on the presence of only a few PDL chert flakes. Small changes one way or the other could have a dramatic impact on the overall percentage of chert flakes.

Looking beyond to the broader study area, we can see that regardless of what trends we might see within SDI-811, this site fails to follow the temporal trend in PDL frequency when compared to other sites. Even the latest component at SDI-811 has less PDL chert than the earliest Archaic component in any other site.

The next lowest percentage of PDL chert found in a Camp Pendleton Coastal Zone site is the 2.5 percent from SDI-13325, a terminal Archaic-Initial Late Prehistoric residential site. Furthermore, SDI-13325 is almost two times farther from the PDL quarry than SDI-811,

demonstrating that distance from source has little impact on the frequency of PDL chert in the Camp Pendleton Coastal Zone.

Table 6-10. Percentage of Debitage Raw Material Types by Site in the Camp Pendleton Coastal Zone

Site & Analytical Unit	*Volcanic (%)*	*Quartz (%)*	*Quartzite (%)*	*Chert (%)*	*PDL (%)*	*Other (%)*	*Count (ct)*	*Age Range (calibrated)*
SDI-811 (AU 1)	70.1	24.8	2.2	0.7	1.5	1.5	137	A.D. 665-1000
SDI-811 (AU 2)	81.5	10.1	4.2	0.8	-	3.4	119	–
SDI-811 (AU 3)	65.1	25.6	7.0	2.3	-	-	43	130 B.C.-A.D. 250
SDI-811 (AU 4)	66.4	24.3	7.9	-	0.7	0.7	153	1395-795 B.C.
SDI-811 (AU 5)	59.3	35.9	3.0	0.6	-	1.2	167	350 B.C.-A.D. 70
SDI-811 (Outside of AUs)	68.9	26.0	3.0	0.3	0.3	1.5	2,628	–
SDI-811 (All Debitage)	68.5	26.0	3.3	0.3	0.3	1.5	3,247	1395 B.C.- A.D. 1000
SDI-811 (Phase II–ASM)	69.9	27.9	0.4	-	1.8	-	502	A.D. 530-970
SDI-13325	82.4	11.0	1.4	1.5	2.5	1.4	1,177	2310-1910 B.C. to A.D. 440-700
SDI-10728, Locus A	81.5	15.3	0.1	0.4	2.6	0.1	916	6415-6000 B.C. to A.D. 1265-1455
SDI-10726 (Unit 5, Lower)	79.5	12.5	-	1.3	5.8	0.9	224	5520-5100 B.C.
SDI-1074	71.4	20.4	1.0	3.1	3.1	1.0	98	A.D. 1280-1430
SDI-4411	70.1	19.5	1.3	3.9	5.2	-	77	A.D. 1400-1510
SDI-10726 (Unit 5, Upper)	83.0	9.4	0.2	0.5	6.4	0.5	607	A.D. 1420-1660
SDI-10728, Locus B	73.0	14.6	-	-	12.4	-	65	A.D. 1375-1675
SDI-4538	51.6	34.9	-	0.5	12.6	0.5	215	A.D. 985-1515
SDI-812/H, Locus A	53.4	26.1	x	18.3[a]	x	2.2	1,090	A.D. 1705-1950
SDI-812/H (Locus C, Unit 19)	27.6	16.1	x	55.9[a]	x	0.4	1,704	A.D. 1530-1705

x Category not used in this analysis
[a] This percentage includes both PDL chert and other cherts.

We will return to the issue of why PDL chert is so rare in SDI-811 in the Summary and Integration section below.

Techniques of Manufacture

Direct evidence for the kinds of tools produced at SDI-811 comes in the form of both cores and debitage. Both of these lines of evidence strongly suggest that the primary tool manufacturing technique used by the occupants of SDI-811 was cobble core reduction.

Core Analysis. While the value of negative evidence can be debated, it is significant that, after the excavation of about 10 m^3 during the testing project (Byrd et al. 1996) and over 20 m^3 of excavation during the data recovery project, not a single bifacially retouched piece or biface has been found at SDI-811. All of the recovered flaked stone artifacts are either cores or flakes that have been modified to some degree. Bifacial cores are rare throughout the entire Camp Pendleton Coastal Zone, with the only recovered example coming from SDI-10726 (Table 6-11).

Table 6-11. Distribution of Core Types

Site &	Unidirectional		Polymorphic		Bidirectional		Bifacial		Other		Total	
Analytical Unit	*ct*	%	*ct*	%	*ct*	%	*ct*	%	*ct*	%	*ct*	%
SDI-811 (AU 1)	1	100	-	-	-	-	-	-	-	-	1	100
SDI-811 (AU 2)	-	-	-	-	-	-	-	-	-	-	-	-
SDI-811 (AU 3)	-	-	-	-	-	-	-	-	-	-	-	-
SDI-811 (AU 4)	2	25	4	50	-	-	-	-	2	25	8	100
SDI-811 (AU 5)	-	-	-	-	-	-	-	-	3	100	3	100
SDI-811 (Outside of AUs)	3	21	9	64	-	-	-	-	2	14	14	100
SDI-811 (All Units)	6	23	13	50	-	-	-	-	7	27	26	100
SDI-811 (Phase II-AMS)	3	60	2	40	-	-	-	-	-	-	5	100
SDI-1074	-	-	2	100	-	-	-	-	-	-	2	100
SDI-4411	1	20	1	20	3	30	-	-	-	-	5	100
SDI-13325	1	10	1	10	3	60	-	-	5	50	10	100
SDI-4538	2	67	1	33	-	-	-	-	-	-	3	100
SDI-10726	3	20	4	27	5	33	1	7	2	13	15	100
SDI-10728	2	29	1	14	2	29	-	-	2	29	7	100

Bifacially retouched pieces are only slightly more common. While it is possible that any bifaces manufactured at SDI-811 were discarded off-site, we will see in the debitage analysis below that this is extremely unlikely for most raw material classes. That is, the lack of bifaces at SDI-811 is due to the lack of biface manufacture on-site.As Table 6-11 demonstrates, the recovered cores indicate that unidirectional core reduction, usually following a radial cobble reduction model like that noted by Eighmey (1996b), or unpatterned core reduction, which was manifested by the polymorphic cores, were commonly used at SDI-811. This verifies the findings of the smaller sample of cores collected during the testing project (Byrd et al. 1996). Examples of cores recovered from SDI-811 can be seen in Figure 6-1.

Debitage Analysis. Debitage analysis provides a way of confirming that core reduction was the main manufacturing technique used at the site (see Core Analysis section above). While some kinds of objective pieces are usually transported away from their location of manufacture, especially bifaces and projectile points, the debitage resulting from their manufacture usually remains. This analysis will focus on debitage completeness, platform type, and width as they relate to determining techniques of manufacture. Where possible, data from other sites in the Camp Pendleton Coastal Zone will be drawn in for comparison. Only the coarse-grained volcanic debitage was considered for this analysis because the low frequency of other types of materials was insufficient for statistical analysis. For example, only twenty-eight quartzite pieces were found in the analyzed AUs, and this small a number of pieces would probably provide misleading information about the frequency of different debitage condition categories in the population as a whole.

Patterns of similarity emerge when we compare the debitage condition (also known as "completeness") percentages for the different analytical units from SDI-811 and the sites in the San Onofre/San Mateo area (Table 6-12). For example, AU 2 (the relatively dense concentration of cultural material in the upper levels of Unit 109) shows many similarities to SDI-4411, the short-term site in the San Onofre area (Byrd et al. 1995).

Table 6-12. Comparison of Debitage Condition

Site & Analytical Unit	*Complete (%)*	*Proximal (%)*	*Distal (%)*	*Split Platform (%)*	*Other (%)*	*Count (ct)*
AU 1[1]	16.5	34.1	17.6	7.7	24.2	91
AU 2[1]	32.6	27.0	3.4	3.4	33.7	89
AU 3[1]	25.0	20.8	4.2	33.3	16.7	24
AU 4[1]	26.1	26.1	13.0	14.1	20.7	92
AU 5[1]	30.4	23.9	13.0	17.4	15.2	92
Total AUs[1]	26.3	27.3	11.3	12.1	22.9	388
SDI-1074	32.7	16.3	8.2	34.7	8.2	98
SDI-4411	46.8	18.2	2.6	3.9	28.6	77
SDI-13325[2]	32.2	10.4	6.4	19.3	31.7	202

[1] The percentages from the AUs of SDI-811 are based on the coarse-grained volcanic debitage only.
[2] From Unit 1 only.

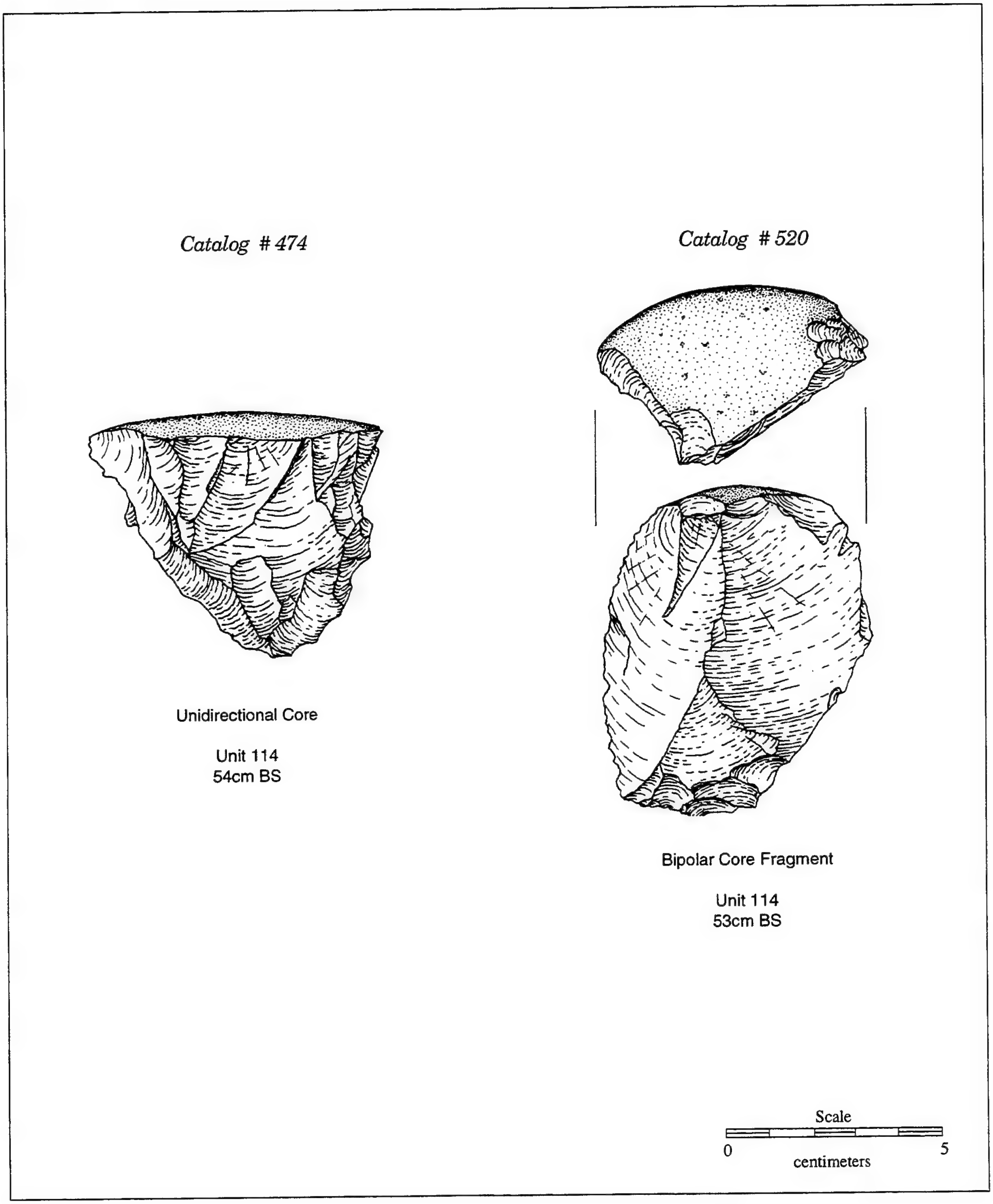


Figure 6-1. Representative Examples of Cores Recovered from CA-SDI-811

Both of these debitage assemblages have low numbers of split platform flakes and large numbers of complete flakes. SDI-1074, a base camp site near San Onofre (Byrd et al. 1995), shares a similar distribution of completeness classes with AU 3, the relatively light concentration of cultural material in the lower levels of Unit 109. Both of these assemblages have high percentages of split platform flakes, suggesting that bipolar reduction or the initial stages of cobble splitting were common in these components. The other analytical units at SDI-811 do not have a specific resemblance to the sites in the San Onofre/San Mateo area. In general, though, they seem to share with SDI-13325 a more-or-less even distribution of debitage in each of the classes. This would suggest that a relatively diverse range of manufacturing activities was undertaken in each of these components.

Another avenue available to us when trying to reconstruct techniques of manufacture is the frequency of different platform types. Once again, data from sites in the San Onofre/San Mateo area is available for comparison to SDI-811 (Table 6-13). The only assemblage from the San Onofre/San Mateo area that has a similar amount of cortical flakes to one of the SDI-811 assemblages was the group of split platform flakes from SDI-13325, where the percentage of cortical flakes was over 50 percent. In fact, the dramatic differences between these data sets leaves one wondering if the categories were defined in the same way.

Table 6-13. Comparison of Platform Type Percentages

Site & Analytical Unit	*Cortical[c] (%)*	*Single (%)*	*Multiple (%)*	*Other[b] (%)*	*None (%)*	*Not Specified (%)*	*Count (ct)*
AU 1[a]	37.4	6.6	1.1	3.3	51.6	-	91
AU 2[a]	55.1	4.5	-	10.1	30.3	-	89
AU 3[a]	54.2	-	-	20.8	25.0	-	24
AU 4[a]	50.0	1.1	-	9.8	39.1	-	92
AU 5[a]	45.6	8.7	-	8.7	37.0	-	92
Total AUs	47.4	4.9	0.3	8.8	38.7	-	388
SDI-1074	19	69	-	-	*	12	48
SDI-4411	14	64	18	-	*	4	
SDI-13325[e]	31.4	49.6	14.6	2.9	*	1.5	137
SDI-13325[f]	52.6	33.3	-	-	*	14.1	57

[a] Based on the coarse-grained volcanic debitage only.
[b] Includes crushed and split but non-cortical platforms.
[c] Includes cortical and split-cortical platforms.
[e] Complete and proximal flakes only.
[f] Split platform flakes only.
* Data for this category not reported in Byrd et al. (1995).

Regardless of the potential lack of comparability between the ASM and SAIC data, they still reveal some important information about trends in techniques of manufacture. Other than flakes that had no platform, the most common platform class throughout most of the analytical units was simple cortical platform debitage (Table 6-14). In most of the components, debitage with split and cortical platforms were the second most common category, but they were more numerous than simple cortical platform debitage in AU 1 and the upper component in Unit 109 (AU 2). Looking at the other end of the scale, debitage with multifaceted platforms were extremely rare. The only example found in this analysis was a coarse-grained volcanic flake from AU 1. (Three other pieces of debitage in other material categories had multifaceted platforms: a quartzite flake from AU 5, an undifferentiated chert flake from outside of the AUs, and a piece of PDL chert from outside of the AUs.) The dominance of the two cortical platform categories indicate that most of the

flake production occurring at SDI-811 was based on the reduction of water-worn cobbles. The lack of multifaceted platforms, which are usually associated with the production of bifaces, signals that the lack of bifaces on the site is probably *not* the result of the bifaces being transported away from the site after their manufacture. They simply were not made at SDI-811.

Table 6-14. Comparison of Platform Type Percentage from Components in CA-SDI-811

	AU 1		AU 2		AU 3		AU 4		AU 5	
Platform Type	*ct*	%	*ct*	%	*ct*	%	*ct*	%	*ct*	%
Cortical	14	15.4	24	27.0	9	37.5	27	29.3	29	31.5
Split & Cortical	20	22.0	25	28.1	4	16.7	19	20.7	13	14.1
Single Faceted	6	6.6	4	4.5	-	-	1	1.1	8	8.7
Crushed	1	1.1	4	4.5	5	20.8	9	9.8	7	7.6
Split	2	2.2	5	5.6	-	-	-	-	1	1.1
Multifaceted	1	1.1	-	-	-	-	-	-	-	-
No Platform	47	51.6	27	30.3	6	25.0	36	39.1	34	37.0
Total	91	100.0	89	100.0	24	100.0	92	100.0	92	100.0

Note: Based on the coarse-grained volcanic debitage only.

One other aspect of Table 6-14 requires comment - the relatively high percentage of debitage with split and cortical platforms in AU 1 and AU 2. Although supporting evidence in the form of discarded wedge-shaped cores is not available from these analytical units, (wedge-shaped core fragments were found in other portions of the site [e.g., Catalog # 317 in Unit 107, Catalog # 520 in Unit 114, Catalog # 586 in Unit 116, etc.], but none were recovered from AU 1 or AU 3), the high percentage of split and cortical platforms may be due to a greater reliance on bipolar reduction in these components. Analytical Unit 1 also has the highest percentage of debitage without platforms. The lack of debitage with platforms in this component may also be a result of bipolar reduction, which tends to produce a large amount of shatter.

The final way in which we can reconstruct techniques of manufacture from the debitage data is through quantile plots of debitage width, which show the range of width values and indicate what percentage of the data is made up of small values. In those cases where debitage assemblages are dominated by many small pieces, as in the production of bifaces, quantile plots of debitage width tend to form slopes that are more-or-less vertical. This is illustrated in Figure 6-2 with data from CA-SBR-5001, a site in the Mojave Desert where the occupants made bifaces out of chalcedony (Hess et al. 1997). A linear smoothing line has been added to reinforce the trend in the data.

A quantile plot reflecting the reduction of cobble cores is shown in the second example from CA-SBR-5001, which is based on coarse-grained sedimentary debitage. Large cores made of the same material were also found at the site. In this case, the quantile plot forms a curve with a more gentle slope, indicating that large pieces of debitage are more common.

We can apply this same technique to the debitage from SDI-811. When we compare debitage by material type from all portions of the site, the differences in the shape of the quantile plot curves are easy to register. The slope formed by the data points from the PDL

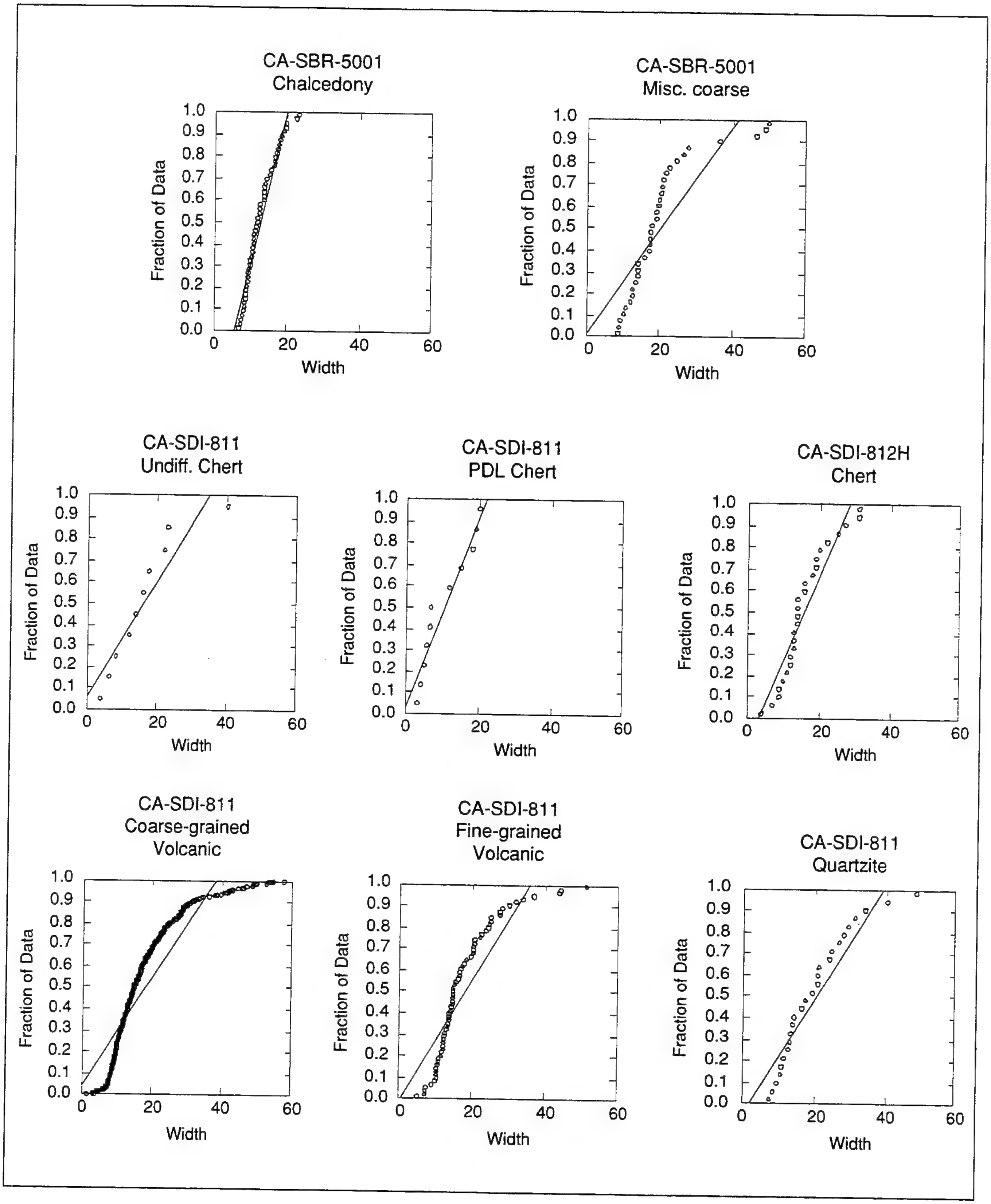


Figure 6-2. Quantile Plots of Debitage Width (mm)

chert debitage is much more vertical than the data points from the coarse-grained volcanics, the fine-grained volcanics, and the quartzite (Figure 6-2). With the exception of a single piece of undifferentiated chert that was relatively wide (throwing off the slope of the smoothing line), this material also conforms to a biface reduction model. Width data for the chert debitage from SDI-812/H is included for comparison, and it shows a similarly steep slope. At SDI-812/H, evidence of biface production in the form of discarded bifaces was much more common than at SDI-811 (Cagle et al. 1996b). The form of these quantile plots indicate that the occupants of SDI-811 may have been manufacturing bifaces out of cherts; however, the lack of broken bifaces made of this material, in contrast to SDI-812/H, shows that they were not making many. In addition, they were not using the locally available coarse-grained materials for biface production. Core reduction is strongly indicated for the coarse material types.

Another way to view this data is to compare the quantile plots for coarse-grained volcanic debitage from each of the analytical units, as well as the volcanic debitage from SDI-812/H (Figure 6-3). These plots show that there was some variation between the analytic units in the width of the debitage. SDI-812/H appears to have had, on average, one of the widest debitage assemblages, and the relatively flat slope of the smoothing line indicates that core reduction created most of this debitage. The slopes of the smoothing lines from the SDI-811 analytical units are steeper than the SDI-812/H plot, but they still indicate that core reduction was pursued in each. Nevertheless, core reduction seems to be most strongly indicated for AU 1 and AU 5, both of which contained discarded cores.

Interpretations. Both the discarded objective pieces and debitage recovered from SDI-811 have demonstrated that the reduction of water-worn volcanic and quartz cobbles was the main flaked stone tool production activity. The high percentage of debitage with split and cortical platforms in AU 1 and AU 2 suggest that bipolar reduction may have been slightly more common in these relatively late dating analytical units, but the basic pattern of tool production remained constant throughout the history of SDI-811. This conclusion should come as no surprise given the prevalence of core reduction in other sites in the Camp Pendleton Coastal Zone. While Eighmey's (1996b) detailed typological analysis of the debitage from SDI-811 suggested that radial cobble core reduction was the main technique used, this analysis has uncovered strong indications that bipolar reduction was also utilized. Evidence for bipolar reduction includes wedge-shaped cores and core fragments, debitage with split and cortical platforms, and an anvil stone with localized pecking (Catalog # 715). While it is possible that the anvil stone was used to help break shells for meat extraction, the interpretation that the anvil stone was used for bipolar reduction is consistent with the recovered debitage and cores.

Regardless of the specific core reduction technique utilized, this strong emphasis on core reduction stands in contrast to what is often associated with hunter-gatherers who moved from site to site throughout the year and who hunted terrestrial vertebrates, conditions that are often thought to favor the use of bifaces (Kelly 1988). Furthermore, while it is easy to conclude that core reduction was the primary manufacturing activity, what sense can we make of the fact that a variety of core reduction techniques were used?

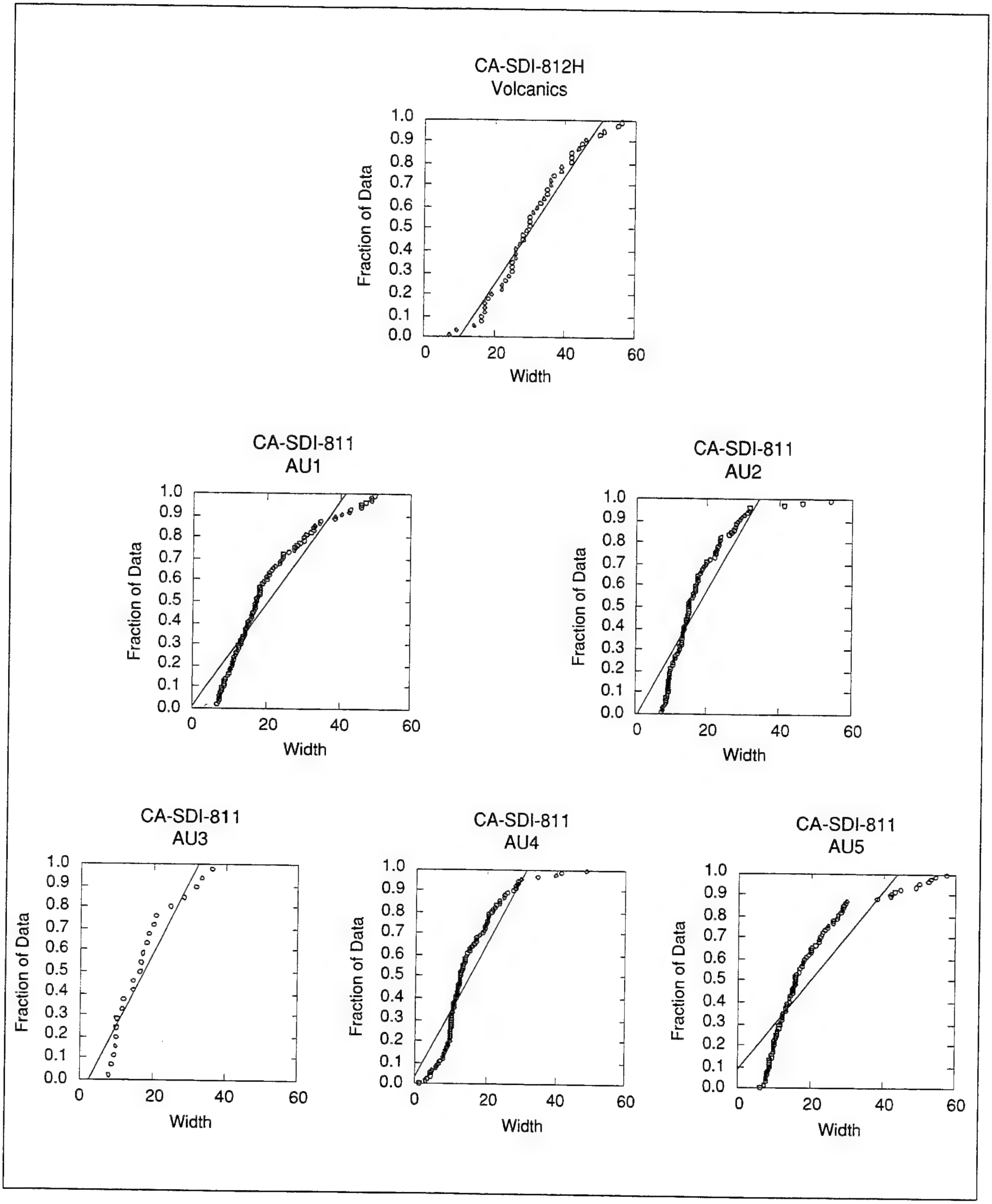


Figure 6-3. Quantile Plots of Volcanic Debitage Width (mm)

In order of frequency throughout the Camp Pendleton Coastal Zone, the three most common core types are polymorphic, unidirectional, and bidirectional. Wedge-shaped bipolar cores are also present in SDI-811, and they may be present in some of the other sites in the project area, as well. To narrow the scope of this discussion, these cores can be placed into two groups: unpatterned cores, which includes the polymorphic and bipolar cores; and patterned cores, which includes the unidirectional and bidirectional cores.

In those cases where archaeologists and ethnographers have been able to observe the manufacture of flaked stone tools by ethnographic groups, unpatterned core reduction using polymorphic or bipolar cores is common (Parry and Kelly 1987). In many lithic technologies used by prehistoric hunter-gatherers, unpatterned core reduction appears to have been dominant, especially in those areas where lithic raw materials are abundant (Johnson 1989). The most patterned or "formalized" core reduction techniques appear in complex hunter-gatherer or agricultural groups where prismatic blades or microblades are driven off of conical cores (Parry 1994). A classic example of this phenomenon comes from the Channel Islands where Chumash groups manufactured microblades for drills crucial in making shell bead money (Arnold 1987). The Levallois-like Cascade Technique of basalt core reduction was found to be common in sites along the Snake River (Muto 1976), but rare in the basalt quarries that produced the material, a phenomenon that Womack (1977) attributed to differences in material availability. He argued that the Cascade Technique tended to maximize the amount of useable material removed from a core, which would be a concern for those groups that were some distance from the source of the material. Kuhn (1991) found that on-site availability of lithic raw material was strongly correlated with the percentage of "informal" or unpatterned cores in Mousterian sites along the western coast of Central Italy. Those sites that had little to no material available on-site tended to have "formal" or patterned cores. Hayden (1989), among others, has also argued that by maximizing the amount of useable material removed from a core, groups can cut their lithic procurement costs and reinvest the savings in subsistence activities, making it energetically advantageous.

At SDI-811, we see an interesting combination of both patterned and unpatterned core reduction. As Eighmey (1996a:315) suggests, the relatively narrow range of core types found in the Camp Pendleton Coastal Zone may be due, in part, to the fact that "there are only so many ways to reduce a coarse-grained beach cobble," but how do we explain the fact that, in some cases, people chose a patterned core reduction technique?

We can dispense with two of the explanations mentioned above fairly quickly. Water-rounded cobbles of volcanic and quartzitic rock suitable for the manufacture of flake tools are readily available throughout the Camp Pendleton Coastal Zone, meaning that occupants of this area would not be motivated by raw material scarcity to adopt material-conservative reduction techniques. Secondly, there are no indications that groups in the Camp Pendleton Coastal Zone had reached the level of socio-economic complexity that might have allowed the development of craft specialists like those envisioned by Parry (1994).

One possible explanation for the use of patterned core reduction techniques at SDI-811 is that it allowed the site's occupants to make flake tools that would be regular in form. Unpatterned core reduction and bipolar reduction, while quick and capable of producing large numbers of flakes, do not produce flakes that are regular in form or size (Parry and

Kelly 1987). Eighmey (1996a) has already suggested that one of the factors accounting for the lack of PDL chert in SDI-811 was the need for relatively large tools. Furthermore, the results of his rudimentary use-wear analysis indicated that "the majority of the tools at these sites were used to reduce and shape moderate to hard materials such as wood and bone" (Eighmey 1996a:313). Given that it is difficult to exert a large amount of force with a small tool, and given that the inhabitants of SDI-811 were working wood or bone (which requires a large amount of force), a radial cobble reduction technique would have allowed the occupants of SDI-811 to efficiently produce large flakes with linear edges.

At the same time, the functional constraints on the flake tools produced in the Camp Pendleton Coastal Zone may not have been stringent at all times, allowing for the use of unpatterned core and bipolar reduction techniques. What is not known is exactly what activities required tools of a specific form, and what activities did not. Because of the difficulty in conducting use-wear studies on coarse-grained materials, we are unable to determine whether flakes produced using a patterned reduction technique were used for different tasks than those produced using unpatterned core or bipolar reduction techniques. Patterned and unpatterned cores appear in sites that were occupied relatively briefly (e.g., SDI-4411) *and* those that appear to have been occupied on a nearly year round basis (e.g., SDI-13325), so the context of the cores is of little interpretive help.

Degree of Refinement

There are three aspects of prehistoric behavior that will be addressed when we compare the assemblages with regard to degree of refinement. First, those assemblages that contain evidence of a wide *range* of stages or artifacts in variable degrees of refinement were probably occupied for relatively long periods of time, providing us with insights on duration of site occupation. Second, using numerical measures of "stage" like dorsal scar count per gram, we can also compare the analytical units with regard to *average* stage of production. Those analytical units that have low average values were locations where earlier stages of production were undertaken. This information can help inform us about differences between the activity areas in the staging of lithic production. Third, comparison of the degree of refinement of each of the material types will allow us to test Eighmey's (1996a) hypothesis about the differences between the use of fine and coarse-grained materials. Because of the difficulties in systematically assessing core "stage," most of this analysis will focus on the debitage. Key characteristics to be studied include the frequency of dorsal cortex classes and dorsal scar density.

Debitage Dorsal Cortex Coverage. The frequency of debitage with cortex has been included in many of the reports dealing with sites in the Camp Pendleton Coastal Zone, but definitions of specific debitage cortex classes has varied, a problem that is frequent throughout archaeology (Sullivan and Rozen 1985; Shott 1994). Byrd et al. (1995) classified debitage as *interior, secondary,* or *primary,* but they failed to provide definitions for these classes. Based on comparisons to data from other nearby sites, it appears that the cortex classes used in Byrd et al. (1995) include both dorsal and platform cortex. That is, a flake would be considered a secondary flake if it had cortex on either its platform or dorsal surface. In the data recording system used in this report, platform cortex and dorsal cortex are recorded as separate attributes. SAIC's preliminary study of the flaked stone artifacts from SDI-812/H (Cagle et al. 1996b) placed debitage into three cortex classes (*bedrock, cobble,*

and *no cortex*), a classification system that is adequate for a rudimentary study but would not provide the detailed data needed here. Eighmey's (1996b) typological analysis often used the presence or absence of cortex as one of the defining characteristics of his debitage types, but cortex class was not set up as a separate attribute. Byrd et al. (1997) simply classified debitage as *cortical* or *non-cortical*.

Because of this variation in cortex class definitions, any intersite comparisons will have to rely on the lowest common denominator in each of these classification systems - debitage with cortex on any surface (including both the platform and the dorsal surface) vs. debitage without cortex. For the purposes of comparison, debitage with cortex on any surface will be placed into the "cortical" class, while debitage lacking cortex will be place in the "non-cortical" class. For information gathered from Byrd et al. 1995, secondary and primary debitage were considered under the "cortical" category while interior debitage was placed under the "non-cortical" category. In the case of Cagle et al. 1996b, bedrock and cobble debitage was considered "cortical" while no cortex debitage was considered "non-cortical". The debitage from Byrd et al. 1997 was used as published, "cortical" versus "non-cortical". Finally, the debitage from the current SDI-811 analysis was considered "cortical" if the platform type was identified as cortical or split & cortical and/or the cortex class was given as decortication, primary, or secondary. The debitage was considered to be "non-cortical" for any other platform type and if the dorsal cortex class was listed as tertiary.

However, before going onto the intersite comparisons, it is important to make use of the highly detailed dorsal cortex data collected as a part of this study for intrasite comparisons at SDI-811. In this paragraph, the terminology follows the dorsal cortex class definitions presented in the "Information Requirements and Methods" section (i.e., decortication, primary, secondary, and tertiary). For all lithic material types at SDI-811, tertiary debitage was the most numerous class, making up 80.0 to 91.3 percent of all debitage included in the sample (Table 6-15).

Table 6-15. Frequencies of Dorsal Cortex Class by Material Type, CA-SDI-811

	Chert		Granitic		PDL Chert		Coarse Volcanic		Fine Volcanic		Quartzite	
Cortex Class	*ct*	*%*	*ct*	*%*	*ct*	*%*	*ct*	*%*	*ct*	*%*	*ct*	*%*
Decortication (100%)	-	-	1	14.3	-	-	18	4.6	3	4.4	-	-
Primary (75-99%)	-	-	-	-	1	9.1	11	2.8	2	2.9	1	3.6
Secondary (1-74%)	2	20.0	-	-	-	-	23	5.9	1	1.5	2	7.1
Tertiary (0%)	8	80.0	6	85.7	10	90.9	336	86.6	62	91.2	25	89.3
Total	10	100.0	7	100.0	11	100.0	388	100.0	68	100.0	28	100.0

Decortication debitage was present only in the debitage assemblages made of the more coarsely grained materials (i.e., granite, coarse-grained volcanics, and fine-grained volcanics). All of these material types are available on-site, and the presence of decortication flakes provides further evidence that they were produced on-site during the reduction of

water-worn cobbles. No decortication flakes made of undifferentiated chert or PDL chert were identified, reinforcing the conclusion that these materials were imported to SDI-811 in a relatively refined state prior to being worked at the site. The percentages of decortication and primary flakes made of coarse-grained volcanics and fine-grained volcanics are nearly identical, suggesting that objective pieces made of the more finely grained materials were not reduced any more intensively than the coarse-grained materials. A X^2 test comparing coarse and fine-grained volcanic debitage with regard to the frequency of debitage in each of the dorsal cortex classes found no significant difference ($X^2 = 2.332$; $df = 3$; $p = 0.506$), but more than 20 percent of the fitted cells were sparse, meaning that the significance tests are suspect (SPSS 1996).

For comparisons between sites in the Camp Pendleton Coastal Zone, the more inclusive "cortical" and "non-cortical" classes described above will be used. Converting the data in each of the previously mentioned reports following the conventions described above results in the data presented in Table 6-16. Comparison to the other site reveals some interesting trends in the frequency of cortex. Almost all of the debitage assemblages made up of coarse-grained materials include over 40 percent "cortical" debitage. Nevertheless, SDI-811, which is directly adjacent to a source of water-worn cobbles and contains abundant evidence of on-site core reduction, has a higher percentage of "cortical" debitage than the other sites. In this light, the percentage of volcanic cortical flakes from SDI-10728 (18 percent) seems low. It may be that the categories used in Byrd et al. (1997) are not fully comparable with the "cortical" and "non-cortical" classes developed here. This examination of the percentage of debitage with cortical surfaces, be they on the platform or the dorsal surface, points out the need for clear definitions of what one means by "cortical," "non-cortical," "interior," etc. Until archaeologists working in the Camp Pendleton Coastal Zone produce debitage data that is accompanied by precise and clear class definitions, intersite comparisons will be frustrated.

A X^2 test comparing the frequency of "cortical" and "non-cortical" flakes in the coarse and fine-grained volcanic material classes found no statistically significant differences between these two datasets at the 95 percent confidence level ($X^2 = 0.450$; $df = 1$; $p = 0.502$). Comparison of the frequency of "cortical" and "non-cortical" coarse-grained volcanic debitage in each of the analytical units also found no statistically significant differences ($X^2 = 1.875$; $df = 4$; $p = 0.759$), indicating that the degree of refinement does not vary between analytical units.

Throughout the sites in the Camp Pendleton Coastal Zone, PDL chert debitage assemblages tend to have fewer flakes with cortex than the volcanic debitage assemblages (Table 6-16). In other words, none of the sites in the study area should be considered "lithic workshops" where the early stages of chert objective piece reduction took place (except possibly SDI-812/H). Chert, regardless of source, appears to have been worked elsewhere to a relatively large extent before being imported to the Camp Pendleton Coastal Zone.

Table 6-16. Percentage of "Cortical" Flakes Based on Both Dorsal and Platform Cortex

Material	*Cortical (%)*	*Non-cortical (%)*	*Count*
SDI-811 Data Recovery			
Volcanic Coarse (AU 1)	58.2	41.8	91
Volcanic Coarse (AU 2)	62.9	37.1	89
Volcanic Coarse (AU 3)	66.7	33.3	24
Volcanic Coarse (AU 4)	56.5	43.5	92
Volcanic Coarse (AU 5)	55.4	44.6	92
Volcanic Coarse (all AUs)	58.8	41.2	388
Volcanic Fine	54.4	45.6	68
Chert, Undiff.	30.0	70.0	10
Granitic	85.7	14.3	7
PDL Chert	9.1	90.9	11
Quartzite	57.1	42.9	28
Total (all materials)	56.8	43.2	512
Previous Excavations			
SDI-1074 (all materials)	42.0	58.0	77
SDI-13325 (all materials)	45.2	54.8	312
SDI-812/H Volcanic	55.0	45.0	555
SDI-812/H, Chert	9.3	90.7	248
SDI-10728, Volcanic	18.0	82.0	1,055
SDI-10728, PDL Chert	2.0	98.0	51

Dorsal Scar Density. Comparisons of material types based on dorsal scar density will rely on data from the data recovery excavations at SDI-811 alone because this measure of refinement has not been used at the other sites. Comparison of debitage from each of the material types allows us to assess Eighmey's (1996a) hypothesis about the extent of refinement varying according to grain size. This will also provide us with information about the range of core reduction "stages" represented in the coarse-grained volcanic debitage assemblages.

Dot density plots are one of the easiest ways to compare the distribution of dorsal scar density values. As Figure 6-4 shows, the coarse-grained volcanic debitage assemblage covers the widest range of log-transformed dorsal scar density values. The distribution of data points shows that both coarse-grained and fine-grained volcanic debitage cover the early and middle stages of reduction. That is, the volcanic debitage was removed from relatively unrefined objective pieces. The least refined of all of the debitage is the very coarse-grained granitic material, followed by the quartzite debitage. At the other end of the refinement scale we have the undifferentiated chert and the PDL chert debitage, which appear to come from relatively late parts of the reduction sequence. Some caution should be exercised, though, in the interpretation of the undifferentiated chert, PDL chert, and granitic data because of the small sample sizes.

Summary statistics for each of the material types can be found in Table 6-17. This table focuses our attention on the differences in the mean log-transformed dorsal scar density for each of the material types. Because of the low sample sizes for most of the material types, the comparison between the coarse and fine-grained volcanic debitage is the most reliable.

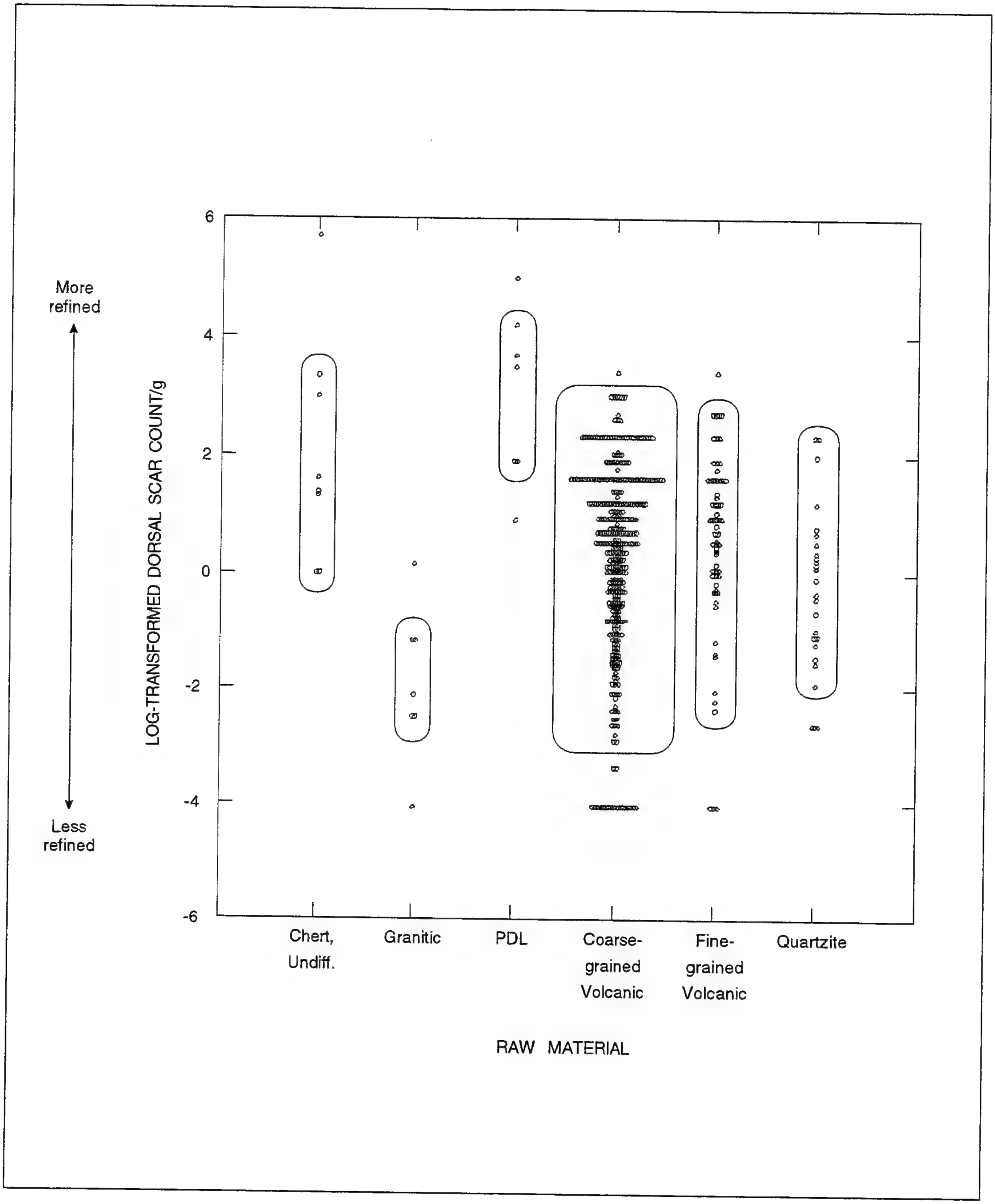


Figure 6-4. Comparison of Dorsal Scar Density by Material Type, CA-SDI-811

Table 6-17. Summary Statistics for Log-Transformed Dorsal Scar Density Data by Material Type, CA-SDI-811

Statistic	*Chert, Undiff.*	*Granitic*	*PDL Chert*	*Volcanic, Coarse*	*Volcanic, Fine*	*Quartzite*
Number of Cases	8	7	7	346	63	26
Mean	2.045	-1.916	3.018	0.181	0.545	-0.292
Standard Deviation	1.912	1.340	1.469	1.663	1.604	1.417

The normal distribution of the log-transformed dorsal scar density data allows the use of Student's t-test, and the results of this comparison show that there is no significant difference between the coarse and fine-grained volcanic debitage in dorsal scar density at the 95 percent confidence level (t = -1.643; df = 88.1; p = 0.104). This confirms the intuitive impression that one gets from Figure 6-4, which shows little difference between the coarse and fine-grained debitage. As we have already seen in the comparison of coarse and fine-grained volcanic debitage with regard to dorsal cortex classes, there was little difference in the treatment of these two material types.

The log-transformed dorsal scar density data for the coarse-grained volcanic debitage is also well suited to comparisons between the five analytical units. Starting with a graphical representation of the data, Figure 6-5 shows that there are some differences between the analytical units in the distribution of log-transformed dorsal scar density values. Focusing on the distribution of the bulk of the data points in each analytical unit (and ignoring the less common extreme values), one can see that AU 5 has the widest range of values, while the narrowest range of values appears to be from AU 3, the relatively sparse component in the lower levels of Unit 109. Nevertheless, the bulk of the data points appear between 2.0 and -2.0 for each of the analytical units, suggesting that the differences between the units may not be statistically significant.

The table of summary statistics for the volcanic debitage in each of the analytical units (Table 6-18) further hints at differences between the analytical units in extent of debitage refinement. The mean log-transformed dorsal scar density values range from a low of -0.092 for AU 1 (Units 100 and 122), to a high of 0.416 for AU 4 (FAR I). Even though AU 3 (Unit 109 lower) and AU 5 (FAR II) appear to have the most divergent spreads of data in Figure 6-5, they actually have fairly similar means (-0.014 and 0.164, respectively). Student's t-test compares the means of normally distributed datasets, and because AU 1 and AU 4 have the most dissimilar means, they were chosen for comparison. The results of the t-test show that the two analytical units are not significantly different at the 95 percent confidence level (t = -1.898; df = 155.0; p = 0.060), but they come close. Given that even the most divergent analytical units are not significantly different, the differences between the other analytical units are not likely to be significant either.

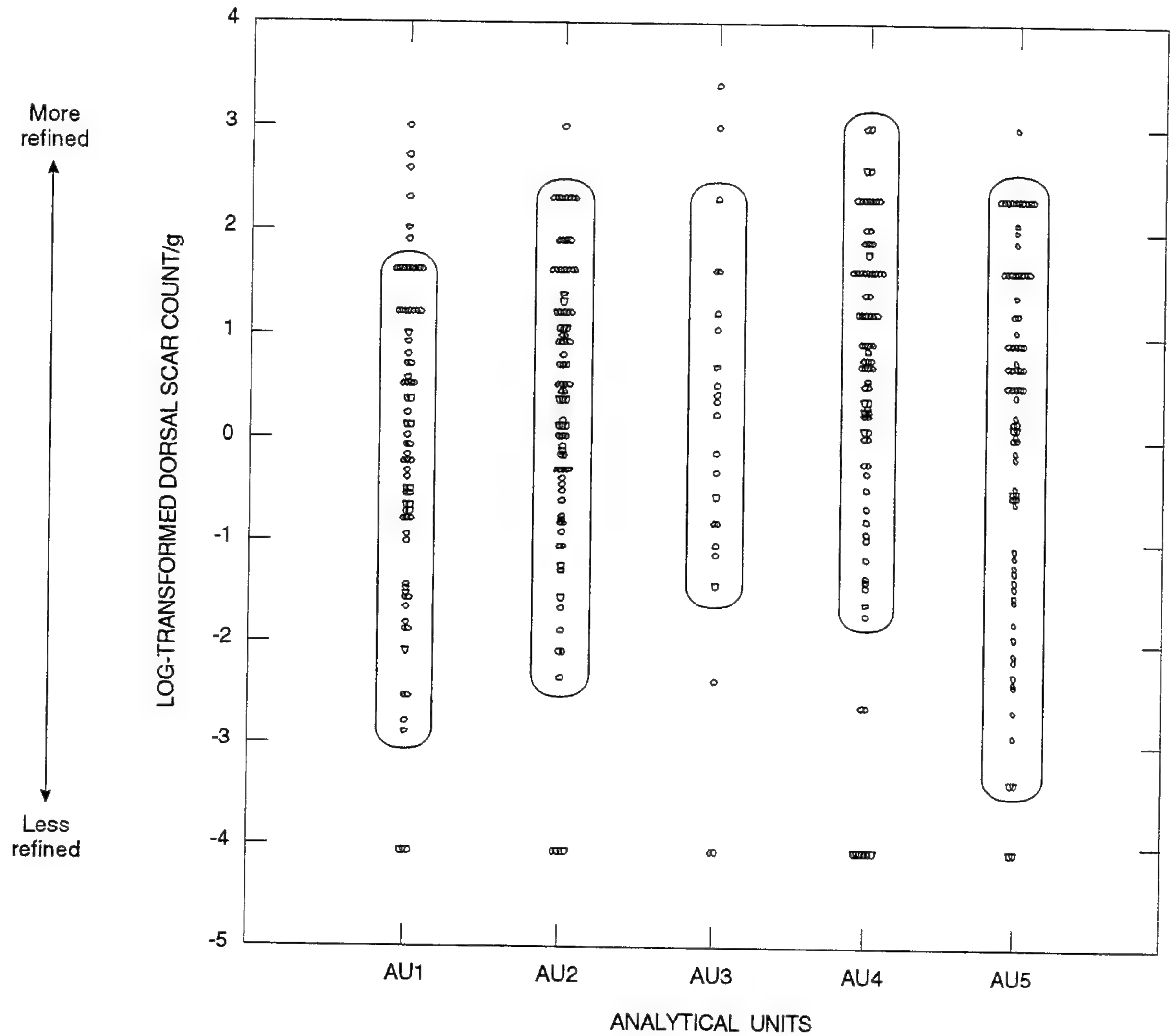


Figure 6-5. Comparison of Log-Transformed Dorsal Scar Density Data for Coarse-Grained Volcanic Debitage by Analytical Unit, CA-SDI-811

Table 6-18. Summary Statistics for Log-Transformed Dorsal Scar Density Data by Analytical Unit (Coarse-Grained Volcanic Debitage Only)

Statistic	*AU 1*	*AU 2*	*AU 3*	*AU 4*	*AU 5*
Number of Cases	75	86	23	82	80
Mean	-0.092	0.265	-0.014	0.416	0.164
Standard Deviation	1.589	1.520	1.905	1.763	1.700

Interpretations. The analysis of the degree of refinement has produced information relevant to duration of occupation, variation from location to location in the "staging" of flaked stone tool manufacture, and differences in the treatment of each material type.

As it was outlined in the introduction to this section, the *range* of reduction stages represented in the debitage data can provide us with information about duration of occupation. The available data will only allow comparisons within SDI-811, which is the only site for which there is information about the range of dorsal scar density values. As seen in Figure 6-5, there are differences between the analytical units in the range of log-transformed dorsal scar density values. Setting aside the component in the lower levels of Unit 109 (AU 3) for the moment, we can compare the range of values in the other four analytical units from which we have better sample sizes. The widest range of values can be found in AU 5, followed by AU 1. The two other analytical units, AU 2 (Unit 109 upper) and AU 4, on the other hand, have more narrow ranges of log-transformed dorsal scar density values. Based strictly on the debitage, it appears that we have two relatively long periods of occupation (AU 5 and AU 1) and two shorter ones (AU 2 and AU 4). The small size of the sample in AU 3 may be partially responsible for the narrow range of values because of the sample size effect (see Jones et al. 1983; Rhodes 1988). Nevertheless, the sparseness of debitage in this analytical unit (see the Site Structure section) also suggests that the duration of occupation represented by this analytical unit was short.

While the range of stages represented in an analytical unit was used to assess duration of occupation, the *average* stage of reduction was used to assess differences between analytical units and sites in stages of production. Data relevant to this question includes not only the log-transformed dorsal scar density data, but also the frequency of "cortical" debitage. No evidence was found for any statistically significant differences between analytical units within SDI-811 in the average degree of refinement. The frequency of "cortical" debitage in each of the analytical units was similar, and a Student's t-test comparing the most divergent analytical units found no significant differences at the 95 percent confidence level. This means that while the range of values may have differed, the average values did not. In other words, a more diverse range of flaked stone tool production stages may have occurred in some analytical units, but the typical activity, producing flakes by reducing water-worn cobbles, was the same.

Using the frequency of "cortical" debitage, we can expand our field of view beyond SDI-811 to the wider Camp Pendleton Coastal Zone. Because of the high percentage of "cortical" flakes at SDI-811 relative to other sites in the Camp Pendleton Coastal Zone (see Table 6-16), it appears that more early stage cobble reduction occurred at SDI-811 than any of the other sites in the Camp Pendleton Coastal Zone. The occupants of SDI-811 may have had easier access to water-worn cobbles than the occupants of the other sites because SDI-811 is directly

adjacent to beachside deposits. Most of the other sites are more inland and are thus further removed from the source of most of the cobbles.

The second topic that was to be addressed was potential differences between material types in the degree of refinement. The small number of undifferentiated chert and PDL chert flakes recovered from SDI-811 make any conclusions regarding these materials suspect, but both the low percentage of flakes with cortex and the high dorsal scar density values for these materials strongly suggest that objective pieces made of these materials were taken to a greater degree of refinement than any of the other material types. This is entirely consistent with the conclusion that the chert debitage represents the waste flakes from the production (or perhaps maintenance) of bifaces, which inherently requires a greater investment of energy in production than the casual manufacture of flakes from cobbles made of coarse-grained materials.

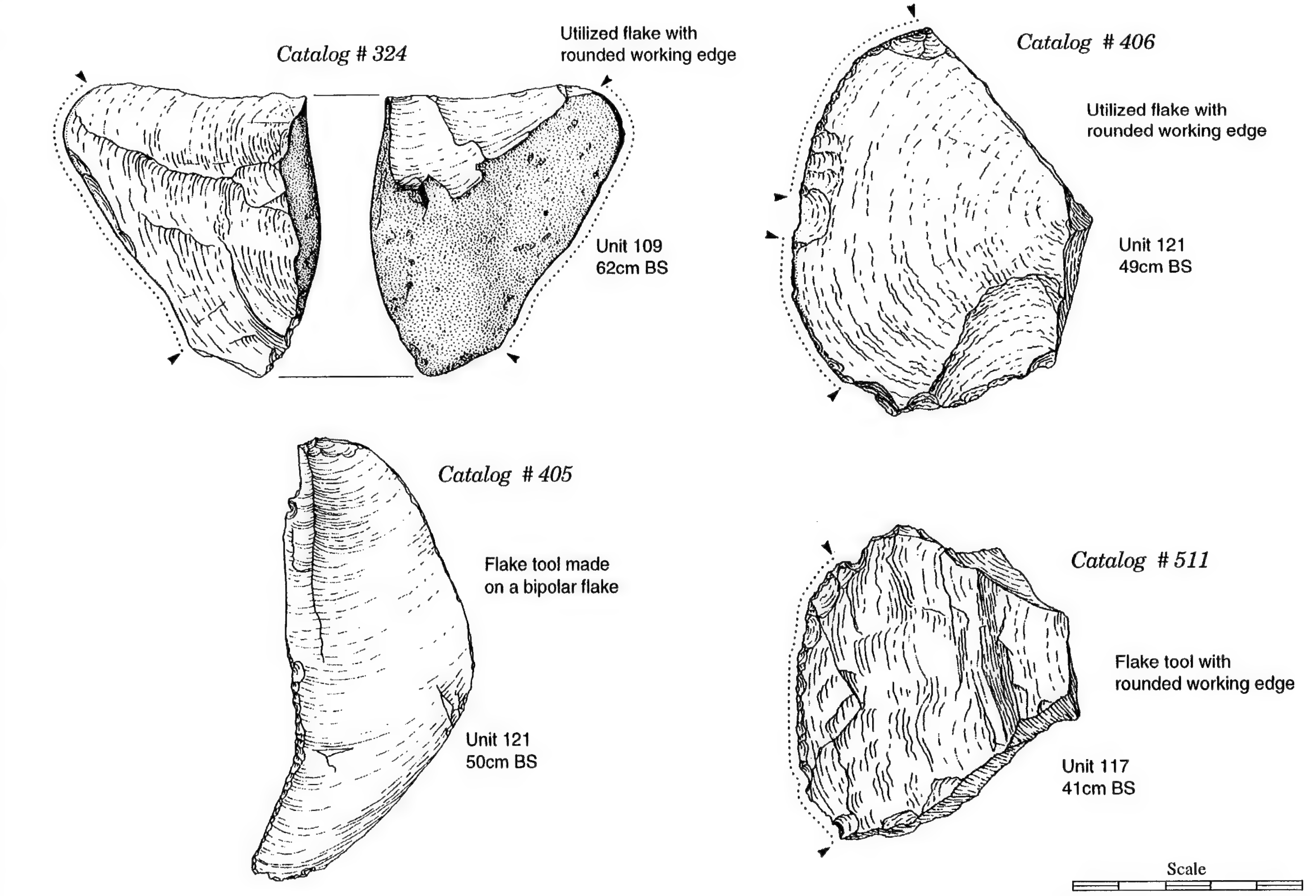
As suggested by Eighmey (1996a:314), close examination of the dorsal flake scars did find a difference between the chert and volcanic debitage, but no such difference could be found between the use of the coarse and fine-grained volcanic debitage. The percentage of "cortical" debitage from each material type was similar, and a Student's t-test failed to find any significant differences in dorsal scar density. When it comes to the amount of energy invested in the refining of objective pieces made of volcanic materials, grain size does not appear to have been a concern for the occupants of SDI-811. This result runs somewhat contrary to intuition, and this topic will be taken up again in the Summary and Integration section because it has important implications for the production goals set by the occupants of the site. Comparisons to other sites with regard to the use of coarse and fine-grained volcanic debitage are not possible at present.

Use-Wear Analysis

The most dramatic evidence of use wear, based on macroscopic inspection of edge damage (please refer to the "Tool Use" section of "Information Requirements and Methods" for more details), was the edge-rounding seen on a utilized flake from Unit 109 (Catalog # 324), a second utilized flake from Unit 121 (Catalog # 406), and a flake tool from Unit 117 (Catalog # 511) (Figure 6-6). All of these tools were made out of durable volcanic materials, so the edge rounding implies repeated contact with hard materials like wood or bone, possibly using a scraping motion. Most of the other utilized flakes and flake tools had non-diagnostic wear in the form of small flakes removed from the working edges.

Assemblage Diversity

The foregoing analyses have used aspects of flaked stone tool production to arrive at conclusions about the role of SDI-811 in regional settlement and subsistence systems. Another tactic commonly used by archaeologists to examine the role of sites in settlement and subsistence systems is to compare the diversity of the assemblages derived from them. Those sites that produce relatively diverse assemblages, after the influence of the sample size effect has been controlled, were probably occupied for a longer period of time than those sites that have less diverse assemblages (Binford 1980). While some analysts (e.g., Ames 1988) look at both the number of artifact classes (i.e., richness) and the relative number of items in each of those classes (i.e., evenness), this preliminary study will focus on richness.



Note: Triangles and dots mark limits of edge–rounding

Figure 6-6. Utilized Flakes and Flake Tools

The goal here is to identify those problems that might interfere with our understanding of diversity in lithic assemblages.

The number and percentage of artifacts in each of the six classes of artifacts from selected sites in the Camp Pendleton Coastal Zone, including each of the analytical units at SDI-811, is presented in Table 6-19.

Table 6-19. Frequency of Flaked Stone Artifacts by Site and Analytical Unit, Camp Pendleton Coastal Zone

Site & Analytical Unit	*Debitage*[e]	*Cores*	*Utilized Flakes*	*Unifacially Retouched Tools*	*Bifacially Retouched Tools*	*Percussing Tools*	*Total*
SDI-811 Data Recovery							
AU 1	137	1	-	1	-	-	139
	98.6%	0.7%	-	0.7%	-	-	100%
AU 2	119	-	1	-	-	1	121
	98.3%	-	0.8%	-	-	0.8%	100%
AU 3	43	-	-	-	-	-	43
	100%	-	-	-	-	-	100%
AU 4	153	8	4	1	-	1	167
	91.6%	4.8%	2.4%	0.6%	-	0.6%	100%
AU 5	167	3	2	1	-	1	174
	96.0%	1.7%	1.1%	0.6%	-	0.6%	100%
Outside of AUs	2,628	14	10	9	-	6	2,667
	98.5%	0.5%	0.4%	0.3%	-	0.2%	100%
All Materials	3,247	26	17	12	-	9	3,311
	98.1%	0.8%	0.5%	0.4%	-	0.3%	100%
Previous Excavations							
SDI-1074	98	2	-	1	1	3	105
	93.3%	1.9%	-	1.0%	1.0%	2.9%	100.0%
SDI-4411	77	5	2	1	1	2	88
	87.5%	5.7%	2.3%	1.1%	1.1%	2.3%	100.0%
SDI-13325	1,346	10	3	7	8	11	1,385
	97.2%	0.7%	0.2%	0.5%	0.6%	0.8%	100.0%
SDI-10726[a]	831	2	5	2	1	4	845
	98.3%	0.2%	0.6%	0.2%	0.1%	0.5%	100.0%
SDI-4538	215	3	-	1	2	3	224
	96.0%	1.3%	-	0.4%	0.9%	1.3%	100.0%
SDI-811[b]	565	5	2	-	-	-	572
	98.8%	0.9%	0.3%	-	-	-	100.0%
SDI-10728[c]	1,124	4	2	3	2	13	1,148
	97.9%	0.3%	0.2%	0.3%	0.2%	1.1%	100.0%
SDI-10728[d]	89	-	1	4	1	1	96
	92.7%	-	1.0%	4.2%	1.0%	1.0%	100.0%

[a] From Unit 5, Locus B.
[b] From ASM's Phase II excavations.
[c] From Locus A.
[d] From Locus B.
[e] Includes all debitage recovered from the excavation units, regardless of material type or size.

These sites were selected for comparison because the data on the number of artifacts was produced using the same typology (e.g., Byrd et al. 1995). Because debitage was present in all of the sites, and thus does not add any information about diversity, it will not be included here. The small size of the flaked stone tool assemblages also means that any conclusions derived from this analysis should be considered tentative.

With the exception of AU 3 (Unit 109 lower) at SDI-811, all of the components included here produced at least one flaked stone tool or worked lithic. One of the best ways to see the relationship between the total number of tools and the total number of types is through an XY scatterplot (Figure 6-7). To make the relationship between the two variables more linear, both datasets have been log-transformed, and a best-fit line has also been added to the scatterplot to emphasize this relationship. The best-fit line also serves to separate those assemblages that are more diverse than expected (above the line), from those assemblages that are less diverse than expected (below the line).

Certain aspects of the XY scatterplot match our expectations. The relatively tight clustering of values around the best-fit line shows that there is a good correlation between sample size (i.e., the number of recovered tools) and the number of identified classes, which is not surprising given the operation of the sample size effect (Jones et al. 1983). A comparison of the analytical units in SDI-811 also follows our expectations with regard to diversity. AU 5, which had the widest range of debitage stages, also has a greater than average diversity of tool types. These two factors suggest that AU 5 represents a longer period of occupation than any of the other components at SDI-811. The other analytical units, especially AU 3, are all less diverse in tool types than expected, leading to the conclusion that they are the result of more brief periods of occupation.

While the scatterplot may vindicate some of our suspicions about the components within SDI-811, it does not match our expectations when it comes to comparisons between sites. Both SDI-13325 and SDI-10728, Locus A, were identified as being the result of relatively long term occupations (Byrd et al. 1995, 1997). Normally, one would expect that residential sites like these would produce relatively diverse assemblages, but the datapoints for both of these sites are below the best-fit line. Turning to two examples of assemblages that derive from short-term occupations, SDI-4411 and SDI-10728, Locus B, one can see that they are above the best-fit line, suggesting that they are more diverse than expected. This also runs contrary to usual patterns because they were thought to be short-duration sites.

This lack of fit between expectations and observations may mean that one cannot make a one-to-one correlation between the diversity of an assemblage and the duration of site occupation in all cases. The diversity of a flaked stone assemblage is actually a reflection of the range of tasks conducted during an occupation, and it is theoretically possible to have a short-term occupation in which a wide range of tasks were conducted. Another factor to consider is the number of people involved in the creation of a single assemblage, irrespective of the amount of time that it took to create that assemblage. If the number of people creating an assemblage was relatively large, this would enhance the probability of greater variability in behavior. While large site populations are usually associated with long durations of site occupation, short but intense (i.e., high population) site occupations are possible.

Although there may be problems assuming that diversity is strictly correlated with the duration of occupation, inspection of the scatterplots suggests that we should also consider

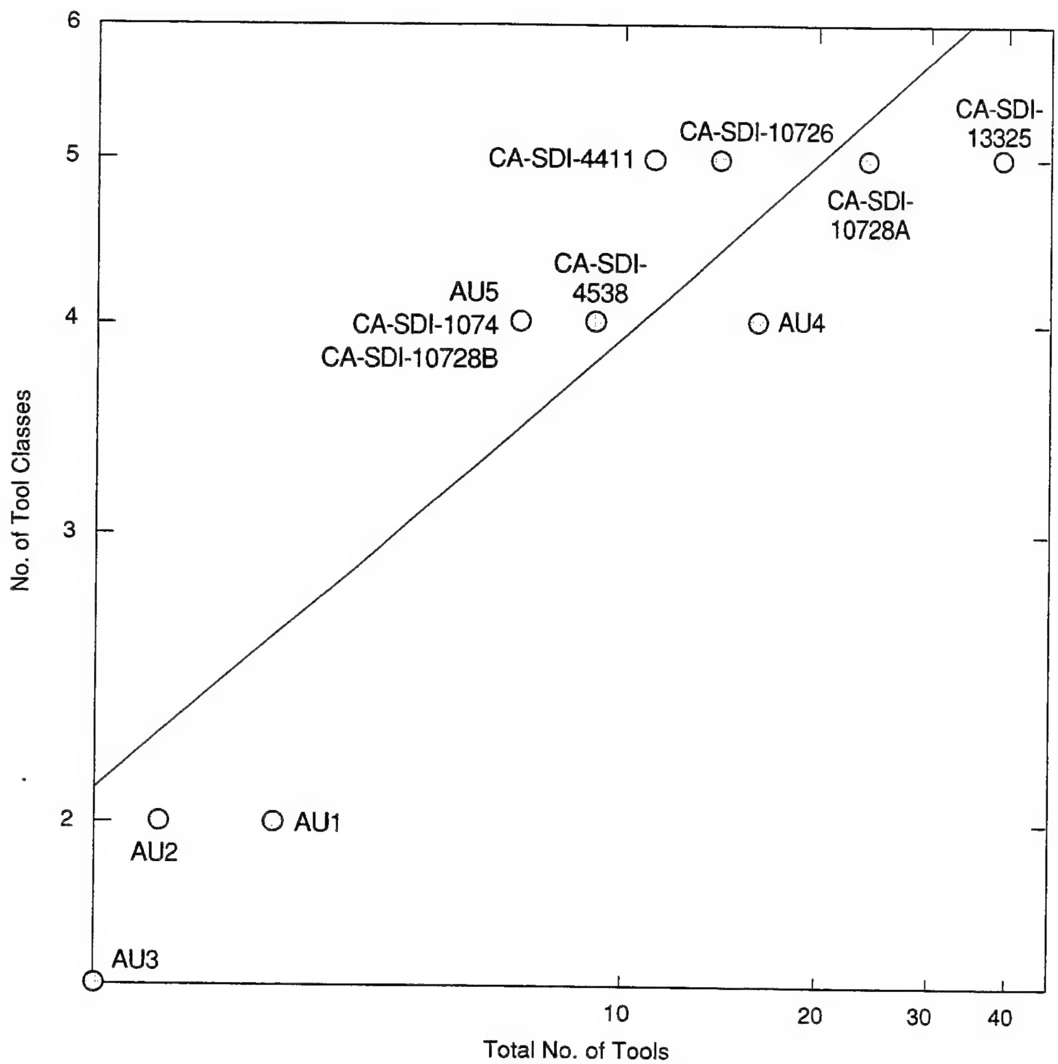


Figure 6-7. Diversity of Flaked Stone Tool Assemblages

the reliability of the statistical analyses. If one were to draw a line from point to point starting with AU 3 and rising up to SDI-13325, one would see that it is consistently above the best-fit line in the middle range of values (except for AU 4), but below it at both extremes. In most regression analyses, this means that the relationship between the two variables is not linear, or it means that some other variable beside the total number of tools is affecting the number of types found in a site or AU. This second condition is usually called "autocorrelation" (Shennan 1990). Because the data has already been log-transformed to allow for a non-linear relationship between the two variables, we cannot accept the first option. This means that there are probably other variables or factors affecting the total number of tool types found in an individual assemblage.

What those other factors might be are not clear, but there are some likely places to start. While it is possible that the four sites mentioned above were misinterpreted, it seems more likely that the failure of the scatterplot to match our expectations and the autocorrelation problem may be due to the restricted number of tool types in the flaked stone artifact typology. Six tool types is a relatively low number, and it probably makes assemblages look more homogeneous than they actually are. While a full exploration of this problem (i.e., the development and testing of a new artifact typology for the Camp Pendleton Coastal Zone) is outside the scope of this chapter, the artifact classes can be broken down into finer categories.

The various subtypes of cores are one of the most developed parts of the existing flaked stone typology for the Camp Pendleton Coastal Zone. Figure 6-8, which compares the number of core types against the total number of recovered cores, shows that breaking down the artifacts into finer categories might eliminate the autocorrelation problem. At the same time, SDI-13325, which should be more diverse than average, still falls below the best fit line, while SDI-4411, which should be less diverse than average, falls above the best-fit line. In other words, the big sites are less diverse than they should be, and some small sites are more diverse than they should be. Some other factor still appears to be influencing the diversity of assemblages, at least in terms of core types.

One other factor that might be constraining the range of tool types found in sites in the Camp Pendleton Coastal Zone is the nature of the lithic landscape. Andrefsky (1994a) found that in those areas where lithic raw materials are abundant but of low quality, as in the Camp Pendleton Coastal Zone, tool producers tend to emphasize informal or expedient tool types, rather than producing a mix of formal and informal tool types. While informal tools might come in a large variety of individual forms, they are devilishly difficult to place into categories like more formal tools (e.g., side-scraper, end-scraper, projectile point, etc.). This means that informal tools often get lumped into categories with generous boundaries, and these "lumpy" categories may be obscuring variation. In sum, it may be necessary to revise flaked stone artifact typologies in the Camp Pendleton Coastal Zone before we can better understand assemblage diversity and its implications for the organization of settlement and subsistence systems.

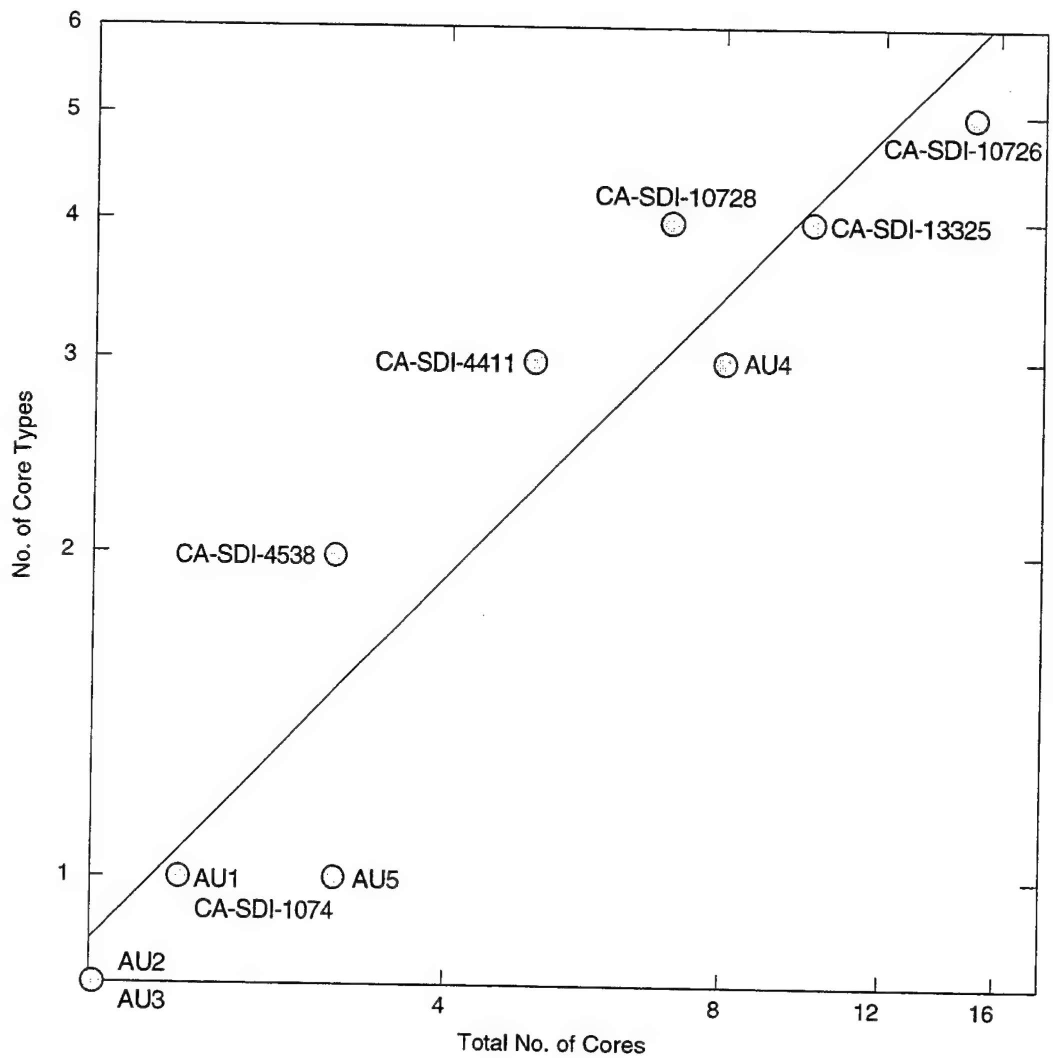


Figure 6-8. Diversity of Core Assemblages

Summary and Integration

Lithic analysis is ultimately most useful to anthropological archaeology if it can provide us with data about what people did, when they did it, and for how long. In short, the goal of this analysis was to tie lithics to livelihood, enabling us to reconstruct the period of site occupation during each of the components and the activities undertaken. Comparison between analytical units at SDI-811 and with sites in other parts of the Camp Pendleton Coastal Zone was seen as crucial in this effort.

Based on this analysis, the most common manufacturing activity at SDI-811 was the production of flakes from locally available coarse-grained cobbles using either a patterned or unpatterned core reduction technique. In a few cases, the occupants of the site manufactured or maintained bifaces made out of imported chert, but these tools appear to have been transported off-site rather than being discarded at SDI-811. The goal of most manufacturing sequences appears to have been the production of large flakes. In some cases, the form of the flakes produced does not appear to have been a concern to the site's occupants, leading to the use of unpatterned core reduction techniques like multiplatform, polymorphic core reduction or bipolar reduction. For other activities, constraints on flake form may have been greater, resulting in the use of more patterned core reduction techniques, especially the radial cobble sectioning technique discussed by Eighmey (1996a, b). Regardless of the technique used, flake size appears to have been one of the primary concerns of the tool makers. This emphasis on size also helps to explain the lack of PDL chert in the site, which is only suitable for the manufacture of relatively small tools. Furthermore, the emphasis on size appears to have led the tool makers to ignore "mechanical" differences between the fine and coarse-grained volcanic rocks available to them. Both types of material were used for the same sort of tools and worked to the same extent.

Analysis of the diversity of flaked stone tool types and debitage demonstrated that the analytical units vary in duration of occupation. In terms of tool types, the most diverse analytical unit is AU 4, which contained the widest range of core forms and the greatest number of utilized volcanic flakes. Analytical Unit 5 came in a close second in tool diversity. This suggests that AU 4, which includes all of the material from the 40-70 cm interval in Units 107, 113, 114, and 115 (a.k.a. FAR I), represents the longest period of site occupation of any of the components. One the other hand, analysis of the debitage suggests that AU 5, which consists of the materials from the 40-70 cm interval in Units 116 and 117 (a.k.a, FAR II), represents the longest period of site occupation. AU 5, while lacking the large number of utilized flakes found in AU 4, does have debitage covering a wide range of stages, including a large number of early stage core reduction flakes. Deciding which of these units represents the longest period of occupation will have to rely on other criteria. The debitage assemblage from Units 100 and 122, which has been labeled AU 1, is nearly as diverse as the debitage assemblage from AU 5, and it also has a large number of early stage core reduction flakes. This indicates a relatively long period of site occupation for this component, as well, but not as long as AU 4 and AU 5.

The two remaining analytical units, AU 2 and AU 3, both appear to represent relatively short periods of site occupation. No cores were found in either of these AUs, and the only tools

were a utilized flake and a hammerstone, both of which were found in AU 2. The range of debitage stages represented in these AUs is relatively narrow, harmonizing with the lack of diversity seen in the tool assemblage.

Discard practices may strongly influence conclusions about the duration of occupation based on the analysis of flaked stone artifacts. It has been assumed here that the flaked stone artifacts manufactured and used during the occupation or occupations that created those artifacts were discarded within the boundaries of the AU created by that occupation or occupations. For example, the period of occupation that generated the materials found in AU 3 may have been as long as the period of occupation that created AU 4 or AU 5, but the flaked stone artifacts created during the AU 3 occupation were discarded primarily *outside* of the bounds of AU 3. Using just the flaked stone artifacts as a guide, this would make AU 3 appear to be a much shorter period of occupation than it actually was.

Working from this same perspective, the diversity of flaked stone tools and debitage in AU 4 and AU 5 may be the result of this area having been used for the discard of secondary refuse. The establishment of discard areas for secondary refuse, particularly flaked stone artifacts that have a high "hindrance value" (Hayden and Cannon 1983), is a hallmark of relatively long periods of site occupation (Chatters 1987; Clark 1991; O'Connell 1987). While it might be tempting to interpret the lower density AUs of the site as representing possible occupation areas from which items were removed to be discarded in AUs 4 and 5, such an interpretation would be mistaken given that each of the AUs produced different dates. Additional dating of materials from the site might help to further refine our knowledge about what parts of the site were simultaneously occupied and might lead to an identification of the occupation areas associated with AUs 4 and 5.

Intersite variation in duration of occupation is harder to address. Part of the difficulty is that most of the other sites have only been tested, meaning that they have not been divided into constituent components. Comparing components from SDI-811 to whole sites from other parts of the Camp Pendleton Coastal Zone creates a conflict because of differences in the units of analysis. With the available information, the flaked stone assemblages from the most diverse of AUs from SDI-811 lacks clear affinities with the long-term residential bases that have been found in the area, especially SDI-13325. Even in less extensive testing projects, these sites have produced a wider range of artifact types, including both bifaces and projectile points that are conspicuously absent at SDI-811. For most of the analytical units, SDI-811 appears to be more like a field camp or location than a residential base.

The activities for which the flaked stone tools were created are not clearly known, but some circumstantial evidence is available. The apparent preference for large tools suggests that the site's occupants were conducting tasks that required the application of a lot of force like shaping wood or bone. While rigorous use-wear studies were not conducted, the working of wood or bone would be consistent with the edge rounding seen on some of the pieces.

Given the presence of terrestrial faunal remains, the lack of artifacts related to hunting is surprising. One would expect at least a few projectile point bases or mid-sections in the site, which would represent broken tools brought back to the site after breakage during hunting forays (Flenniken 1991), but that is not the case. This phenomenon is probably not an

accident of sampling because large portions of SDI-811 have been excavated – hunting tools simply are absent or, at most, very rare.

At least two explanations exist for the lack of hunting-related flaked stone artifacts at SDI-811. The first is that the occupants of the site dispatched game using something other than the bow and arrow or dart and atlatl. Bean and Shipek (1978:552) report that the ethnographic Luiseño, who occupied the study area at the time of Spanish contact, held communal drives when large amounts of meat were desired. Although the means of killing the driven animals is not reported, other California groups using this technique sometimes relied on clubs to kill the trapped animals (Bean and Smith 1978; Levy 1978). If the terrestrial faunal remains in the site are the result of drives, the club-killing hypothesis might have some validity, but an assessment of the age structure of the terrestrial fauna in the site would be crucial in addressing this hypothesis. Drives tend to round up large numbers of individuals, and might capture a wider range of ages than conventional, single-hunter stalking.

The second possibility is that flaked stone projectile points were used to dispatch the game found in SDI-811, but the points were discarded in another site, while the bones (and attached cuts of meat) were brought to SDI-811 for consumption. The broken points used in killing the game and the low-value bones probably would be discarded at the kill site, while the point bases and the foreshafts to which they were attached would be returned to the residential base with the cuts of meat (Flenniken 1991). After some additional processing, the cuts of meat were transported to SDI-811 without the flaked stone points, which would have been reworked or discarded at the residential base.

Evaluation of this possibility would require more extensive excavations in the sites that are close to SDI-811 with an eye toward identifying those places where projectile point manufacture and maintenance occurred. If SDI-811 is a short term site, we should also find evidence of the earlier stages of butchery in the more permanent site. If flaked stone artifacts from SDI-811 could be refitted to artifacts in the residential base, it would help establish linkage between the two sites.

In sum, SDI-811 represents a frequently reused location in a larger settlement and subsistence system. Until sufficient and comparable data is collected from the other parts of this system, the site's place in the overall pattern will remain unclear.

6.2 MISCELLANEOUS STONE ARTIFACTS

Groundstone

Only one piece of groundstone (Catalog # 704) (Table 6-20) was collected during the data recovery program, a mortar rim fragment produced out of vesicular basalt. Based on the curvature of the fragment, it is estimated that the mouth of the mortar originally had an eight inch diameter. The artifact was found on the surface of the site, between Unit 123 and Trench 102.

Table 6-20. Spatial Distribution of Miscellaneous Stone Artifacts

Unit	*Depth (cm)*	*Groundstone*	*Tarring Pebbles*	*Comments*
Surface	-	1	-	Vesicular basalt mortar fragment
108	50-60	-	1	
109	70-80	-	1	
114	61 cm bs	-	1	AU 4
115	65 cm bs	-	1	AU 4
121	59 cm bs	-	1	
Auger 109	55 cm bs	-	1	Between Units 107 and 108

Earlier work at the site uncovered one mano fragment and five pieces of a single portable mortar from Unit 2 (Byrd et al. 1996). The mano was composed of a granitic cobble while the mortar fragments were a fine-grained vesicular basalt (Byrd et al. 1996:193). These items were recovered below 80 cm in depth. The mortar fragment found on the surface during the current testing probably does not match with the mortar fragments recovered from the lower reaches of Unit 2, given their disparate recovery locations.

Tarring Pebbles

Six tarring pebbles were recovered during the data recovery program (Table 6-20). These artifacts consist of small, rounded pebbles or pebble fragments covered with asphaltum. No tarring pebbles have been reported from previous excavations at the site (Byrd et al. 1996; Cagle et al. 1995). These artifacts may have been used for water-proofing basketry. The tarring pebbles were scattered throughout the site and display no obvious spatial patterning.

6.3 CERAMIC ANALYSIS

Forty-seven ceramic and brick/tile fragments were recovered during the data recovery program. All but two of the sherds were recovered from surface or plowzone contexts.

Forty-three fragments (52.63 grams) of Tizon Brownware (TBW) were identified from the collection (Table 6-21). Analytic methods used on the brownware fragments entailed macroscopic examination of the current surfaces under 10x magnification. The paste of each sherd was examined for variety and amount of mineral inclusions, degree of angularity, amount of mica, and evidence of cavities indicative of fiber temper. Surface treatments were also examined. Rim sherds or other diagnostic body sherds were not recovered. None of the sherds exhibited any evidence of fiber temper or heavy carbon streaking indicative of wares produced at various mission sites. Based on the types and uniformity of the mineral inclusions found for each sherd, it can be suggested that all of the pottery recovered at the site originated from a common clay source. Evidence of importation of wares outside the area was not found.

Table 6-21. Tizon Brownware Assemblage from CA-SDI-811

Unit	Depth (cm)	Screen Size	Temper	Count	Weight (g)	Grain Size (mm)
100	0-20	1/4	-	1	0.3	0.2
101	0-20	1/4	Angular-quartz	3	2.8	0.2-0.4
101	20-40	1/4	-	3	2.5	0.2
102	0-20	1/8	Mica/schist	1	0.6	0.2
102	20-40	1/4	Angular-quartz	2	0.9	0.2
103	20-40	1/4	Angular grain, mica, feldspar	4	3.8	0.2-0.4
105	0-20	1/4	Angular-quartz	5	6.7	-
105	0-20	1/8	Angular-quartz	2	0.3	0.2
106	20-40	1/8	-	1	0.3	0.2
107	0-20	1/4	Angular	1	1.3	0.4
108	0-20	1/4	-	1	0.2	0.2
109	0-20	1/4	Angular-quartz	1	1.7	0.4
110	20-40	1/4	-	1	0.4	0.2
111	20-40	1/4	Angular-quartz	2	3.5	0.2
112	0-20	1/4	Angular feldspar	5	3.2	0.2-0.4
112	20-30	1/4	Angular feldspar	3	2.0	0.2
113	20-40	1/4	Angular mica, schist	1	2.1	-
123	0-20	1/4	Angular	1	0.5	0.2
123	20-40	1/4	Angular feldspar, quartz	2	1.3	0.2
Aug-103	10-20	1/8	Angular-quartz	1	5.2	0.4
CS-102	40-50	1/4	Angular-quartz	1	0.3	0.2
SC-03	Surface	-	Angular-quartz, feldspar	1	9.2	0.4

Sherds from SDI-811 contain angular to subangular grains of quartz and feldspar, with flecks of mica seen in 20-30 percent of the sample. Grain size ranged between 0.2 to 0.4 mm. All of the sherds were extremely small (average weight ranged between 0.2-0.5 gm/sherd). Using thickness as the only available relative measure, it appears that all of the recovered sherds represent wall fragments rather than portions of a vessel's base. The lack of identifiable rim sherds or basal fragments made it impossible to estimate minimal vessel counts or functions. Evidence of repair, modification, and/or reuse was not found.

The small number of sherds collected suggests that pottery was not the dominant type of container used at the site. Containers made from other materials, such as basketry, were probably used for storage and cooking.

The Tizon assemblage recovered from SDI-811 and SDI-10,726 (Byrd et al. 1996) exhibited similar attributes such as a lack of distinctive traits, low frequency, and the probable use of local clay sources. Similar fragments of Tizon Brownware have also been recovered from SDI-13,325 (Byrd et al. 1995), SDI-812/H (Cagle et al. 1996b; Rasmussen and Woodman 1998), SDI-14,482 (Cagle et al. 1996a), and SDI-10,723 (Cagle et al. 1996a).

All of the Tizon Brownware sherds examined were considered to be pre-Mission contact. Although efforts to assign entry dates to Tizon have met with considerable problems, an introductory date of A.D. 1200-1300 is suggested for northern San Diego County (Laylander 1992) Ceramics, however, did not become common in the area until the ethnohistoric period

(True and Waugh 1983). Traditional methods of pottery making were identical to those of other Southern California groups (Rogers 1936). Vessels were built up in coils that were fused together by slapping with a wooden paddle against a cobble or ceramic anvil. After the pots were allowed to dry, they were fired in pits (Sparkman 1908:202) or in open fires (Drucker 1937:22), at relatively low temperatures and for a short duration of time.

The Tizon Brownware assemblage was recovered from 14 of the 24 excavation units. Sherds were broadly scattered across the site with little evidence of clustering or association with a special-use area. Discrete features, such as hearths, were not associated with these units. When the various excavation levels are combined into 20 cm blocks, the vertical distribution of sherds at the site exhibits the following pattern: 23 sherds were recovered in the 0-20 cm level, 19 at the 20-40 cm level, and 1 below 40 cm. In general, the ceramic fragments were scattered throughout the site horizontally, but were primarily confined to the 0-40 cm plowzone.

Four fragments of Mission Period tile or brick, which is technically not considered to be a ceramic, were recovered from the site. Instead of being fired like Tizon Brownware, Mission Period tile and brick were usually formed-shaped in a mold and set to dry in the sun. In addition to the difference in manufacturing technique, these fragments were made from a different type of clay and temper than the Tizon Brownware. Of the four fragments found at the site, three came from Unit 108 (0-20 cm) while the fourth was recovered from Unit 113 (40-50 cm). All of the fragments were very small, with weights ranging from 0.2 to 3.5 grams. The four fragments were fairly undiagnostic.

Overall, four fragments of possible Mission Period brick or tile and forty-three fragments of Tizon Brownware were recovered during the 1997 excavations. Although the radiocarbon samples from SDI-811 date no later than A.D. 1000, the presence of these ceramics suggests the possibility of a later, perhaps ethnohistoric site occupation.

7 VERTEBRATE FAUNAL ANALYSIS

Jean Hudson

Karen A. Rasmussen

7.1 INTRODUCTION

The vertebrate collection from SDI-811 is of special interest due to the coastal location of the site and the calibrated radiocarbon dates for the current sample, which range from approximately 1200 B.C. to A.D. 900. This site provides information about the role of coastal sites in the subsistence and settlement strategies of the people occupying the region associated ethnographically with the Luiseño from the end of the Archaic through the early part of the Late Prehistoric.

Data presented here suggest that coastal people pursued a mixed subsistence strategy, using deer and rabbit in combination with marine resources such as fish, shellfish, and marine mammals. Seasonal data suggest that SDI-811 may have been used primarily during the spring, summer, and fall months. Spatial patterning in bone density and bone modification, and the diversity of taxa represented, are consistent with short-term residential use, and suggest that site use may have changed over time.

The analysis that follows presents new data from five distinct analytic units at the site and compares these data with those previously recovered from this site and from three other coastal sites in northern San Diego County. The three sites chosen for comparison are roughly contemporaneous. They are SDI-13325, -4538, and -10726 (see Figure 1-6 and 1-7).

7.2 RESEARCH ISSUES

Regional research questions focus on the nature of the use of coastal sites by the Luiseño and their predecessors. Of special interest is whether the coast was part of an annual round that had an important inland component, or if the coast was occupied on a nearly year-round basis. Also of interest is whether this pattern changed over time.

Related research questions concern the interpretation of the activities carried out at the site, the ways in which vertebrate resources contributed to diet and to other aspects of daily life, the range of habitats exploited, and the season of site use. These questions can be summarized as follows:

- Was the site occupied on a short-term basis for the procurement of specific resources or was it occupied on a semi-sedentary basis as a residential site?
- What season or seasons of occupation are evidenced?
- What resource habitats were exploited and how were they ranked?

- What types of food procurement and processing activities took place at the site?
- Do the activities appear spatially and/or temporally discrete?
- Is there evidence for non-food uses of vertebrate resources?
- Is there evidence for changes in site use over time?

7.3 BACKGROUND

The radiocarbon dates associated with the analyzed material from SDI-811 place it temporally in a transitional period, which includes the latter part of the Archaic and the early part of the Late Prehistoric. This archaeological time period may predate the adaptations associated with the Luiseño; however, data on the Luiseño continue to be an important source for subsistence and settlement models for the region.

Ethnographic and ethnohistoric references to Luiseño coastal sites are rare. In characterizing Luiseño subsistence patterns, Bean and Shipek (1978) and Sparkman (1908) suggest differences between those living inland and those living on the coast. Sparkman's use of the phrase "people who lived permanently on the coast" provides support for the idea that at least some Luiseño maintained a nearly year-round residence in coastal sites.

> While fish formed an unimportant article of food for those who lived inland, it was the chief dependence of those who lived on the coast. The coast people also consumed large quantities of shell fish of several species (Sparkman 1908:200).
>
> The largest game animal was the black-tailed deer, formerly very abundant... The principal animal food probably always consisted of jackrabbits and rabbits... But an exception must be made of the people who lived permanently on the coast, whose chief flesh diet was fish and mussels (Sparkman 1908:198).

Previous studies of coastal sites in northern San Diego County have shown that a mixed emphasis on marine and terrestrial fauna is common, and the use of marine resources drops significantly for more inland sites (Hudson et al. 1996). Comparisons based on bone weight suggest that fish, large game such as deer, and small game such as rabbit, played a relatively equal role, their exact rankings varying with local ecology. To date, the archaeological data have not supported Sparkman's descriptions of fish as the primary resource at coastal sites.

A mixed subsistence strategy fits well with regional models for the Archaic, which characterize this time period as one of diversification of resource strategies rather than specialization on any one resource. The inclusion of deer and rabbit at coastal sites suggests that the hills and valleys stretching inland from the sites were an important part of the catchment area. Marine mammals, including sea lion, fur seal, and sea otter, were used at some sites, but do not appear to have been a major focus of subsistence activities.

Non-food uses of local fauna are also important to consider in interpretations of vertebrate remains. Deer, rabbit, and sea otter were prized for their hides as well as their meat.

> The capes were sometimes made of rabbit skins, cut into strips and woven with a woof of twine. Others were made of deer-skins, and some of sea otter skins. These latter were the most highly prized, but were not common, except perhaps on the coast (Sparkman 1908:201).

Deer bone and antler was often a source for tools (Iovin 1963). Bird and rabbit bone were good sources for tubular limb bones useful in making bone beads and hairpins. Turtle, although reportedly taboo as a food item (Kroeber 1925), had important ceremonial use (Bean and Shipek 1978, Sparkman 1908).

> . . . little shells of small turtles a couple of them stuck together, and with some little stones inside, called *Paail* (Harrington 1934:39, cited in Iovin 1963:104)

Birds were a source of feathers, often used for ornamentation and in ceremonial contexts (Bean and Shipek 1978; Iovin 1963).

7.4 MATERIAL AND METHODS

The faunal material from the 1/4" mesh of the 24 excavation units as well as the 1/4" and 1/8" mesh from the column samples was selected for detailed faunal analysis. This comprised a sample of 4,064 fragments of bone, weighing 1,001.3 grams. Summary data on the horizontal and vertical distribution of bone is tabled in Chapter 5 and reviewed briefly in this chapter. A subsample representing the five analytic units at the site has been analyzed in more detail. This subsample consists of all 1/4" bone from the excavation units and all 1/4" and 1/8" bone from the column samples associated with AU contexts. This subsample contains 1,455 fragments weighing 399.85 grams. The assemblage was first separated into fish and non-fish categories. The fish bone was identified by Dr. Karen Rasmussen. The non-fish assemblage was examined by Dr. Jean Hudson. The detailed non-fish vertebrate catalog is provided in Appendix B, and the fish catalog can be found in Appendix C.

Fish bone fragments were identified to the most specific taxonomic level possible. In addition, a record was kept on element type, siding, counts, weight (to the nearest 0.01 gram), and signs of modification. The elements most useful in fish identification include the dentaries, premaxillae, pharyngeals, otoliths, and the vertebrae (Casteel 1976; Wheeler and Jones 1989). The inclusion of the 1/8" material from the column samples was very important for the potential recovery of small diagnostic fish remains, such as sardine or anchovy vertebrae.

Fish identification was based on the vertebrate comparative collection housed at the Department of Anthropology, University of California, Santa Barbara. Taxonomic nomenclature follows Eschmeyer et al. (1983). Although the collection was identified to the most specific taxonomic level possible, many of the remains had to be left at a family level or greater. Some of the remains were simply too fragmentary to identify with a greater degree of accuracy, and some of the fish elements were simply non-diagnostic to species level. These remains were left as Teleostei (bony fish) or Elasmobranchii (cartilaginous fish). Other remains could not be more precisely identified because of the incomplete nature of the comparative collection. For example, the UCSB collection does not contain the full range of

croaker species for this area. The croaker remains, therefore, were identified only to the family level.

Identifications of mammal, bird, and reptile remains were made using comparative collections housed at the Biology Department and at the Archaeology Laboratory at California State University, Bakersfield, and Hudson's personal collection. Identification was to the most specific level possible given the available comparative collections. Due to fragmentation and mineral deposit, much of the bone could be identified only to broad categories of taxonomic class and size. Size categories were defined according to the following criteria. For mammals, large is deer size or larger, medium is smaller than deer and larger than jackrabbit, small is jackrabbit size or smaller; in some cases two categories were possible, yielding additional designations of medium-large and small-medium. For birds, large is goose size or larger, medium is duck size, and small is sparrow size or smaller.

Analysis of non-fish vertebrate remains was carried out in two stages, a preliminary sort aimed at identification of the taxonomic categories represented in each provenience, followed by a more detailed analysis with counts and weights of all identified elements.

Screen Size

Screening strategies can have important effects on the bone assemblage recovered, the amount of bone identifiable at a more specific level, and the identification of very small taxa (Shaffer 1992; Shaffer and Sanchez 1994). Quarter-inch mesh typically allows greater volumes of deposit to be processed and analyzed and produces larger samples of more identifiable bone, allowing for more robust interpretations of broad patterns of cultural behavior and identification of relatively rare constituents. Eighth-inch and finer mesh typically allows the recovery of smaller-bodied fauna, such as small birds, rodents, reptiles, and fish. For coastal sites, the identification of sardine and anchovy is especially critical and often strongly dependent on mesh size (Johnson 1982). The ideal sample is often a mix of both coarse and fine meshes.

Previous excavations at SDI-811 included 1/16" samples and the effect of screen size on this site and others in the region have been reported elsewhere (Hudson et al. 1995, 1996). At SDI-811 the three most important resources--fish, small mammal, and large mammal--remain relatively equal regardless of mesh size. A more critical concern is whether very small-bodied fish, such as sardine and anchovy, become essentially invisible in the absence of 1/16" mesh. The previous analysis of SDI-811 identified 8 anchovy and 12 sardine/herring bones out of 398 fish bones in the 1/16" materials, and none out of 174 fish bone in the 1/8" materials; this may be due to a combination of screen size, sample size, and the probability of recovering items that are rare in the deposit.

The assemblage analyzed here consists of all 1/4" bone from excavated units and all 1/4" and 1/8" bone from the associated column samples. In addition, the 1/16" mesh residue from all of the column samples was scanned by Karen Rasmussen for any fish taxa not represented in the 1/4" and 1/8" bone assemblages, but no new taxonomic species, such as anchovy or sardine, were encountered. Overall, the inclusion of 1/8" did not significantly affect the ranked importance of the major faunal categories when measured by weight. Although the lack of anchovy and sardine/herring in the current assemblage may be due to screen size,

sample size, the lower probability of recovering rare items, or the particular areas of the site excavated, it should be noted that the small sample recovered during the previous testing in conjunction with the negative results from the current testing demonstrate that these small schooling fish never composed a large portion of the local economy.

Where comparisons are made between SDI-811 and other sites in the region, they are standardized to 1/8" recovery. The samples are not completely comparable, due to differences in the percentage of 1/8" bone and differences between wet and dry screening techniques, as well as differences in sample size. With these caveats in mind, the comparisons can serve simply as a starting point for devising testable models of regional patterns.

7.5 RESULTS

The vertebrate assemblage is moderately diverse, with 27 distinct taxa represented. These include nine mammals, three birds, two reptiles, and at least thirteen fish. The mammals include terrestrial fauna, such as deer, coyote or dog, jackrabbit, brushrabbit or cottontail, and pocket gopher, as well as marine mammals, such as pinniped and sea otter. The bird bone has not been identified at the species level, but includes at least three distinct taxa based on size, one of which represents the order Galliformes. The reptiles represented include western pond turtle and undifferentiated snake. The non-fish vertebrate taxa are listed in Table 7-1.

The fish include kelpfish, surfperch, sheephead, croaker, pacific bonito, pacific mackerel, bass, barracuda, halibut, yellowtail family, soupfin shark, shovelnose guitarfish, and bat ray. In addition, six fish fragments labeled as undifferentiated Teleost may belong to rockfish (*Sebastes* spp.), but the remains were too fragmentary to make a positive identification. The only Carangidae vertebra in the collection probably belongs to a yellowtail. The Bothidae remains are most likely California halibut, and those labeled Pleuronectiformes belong to one of the many small flatfish species. Finally, one of the Elasmobranch teeth is similar to those of a swell shark while the other two probably belong to soupfin shark. All fish taxa represented are listed in Table 7-2.

The density of bone varies across the site, as noted in Chapter 5 (see Table 5-1), suggesting variation in the way different parts of the site were used. Summary data for each of the five analytic units is presented in Table 7-3. These data represent a combination of 1/4" and 1/8" bone. Comparison of SDI-811 bone density with that at two other sites (SDI-4538 and SDI-10726), located on or near the coast within roughly 5 km of SDI-811, suggests that SDI-811 may be the best candidate for semi-sedentary use. However, greater densities of food remains may result from frequent re-use of the site rather than long periods of continual occupation. As detailed in Chapter 5, SDI-811 exhibits structure in discard patterns, as represented by midden composition, but its interpretation is complicated by the associated temporal variation.

Table 7-1. Non-Fish Vertebrate Taxa

MAMMALIA
- Order Artiodactyla (Even-toed Hoofed Mammal)
  - **Cervidae** (Deer)
    - *Odocoileus hemionus* (Mule Deer)
- Order Pinnipedia (Seals & Sea Lions)
  - **Otariidae** (Sea Lion and Fur Seal)
- Order Carnivora (Carnivore)
  - **Mustelidae** (Weasels, Skunks, etc.)
    - *Enhydra lutris* (Sea Otter)
  - **Canidae** (Dogs, Wolves, & Foxes)
    - *Canis latrans* spp. (Coyote or Dog)
- Order Lagomorpha (Rabbits, Hares, & Pikas)
  - **Leporidae** (Rabbits & Hares)
    - *Lepus californicus* (Blacktail Jackrabbit)
    - *Sylvilagus* spp. (Desert Cottontail or Brush Rabbit)
- Order Rodentia (Gnawing Mammals)
  - **Sciuridae** (Squirrels)
    - *Spermophilus beecheyi* (California Ground Squirrel)
  - **Geomyidae** (Pocket Gophers)
    - *Thomomys bottae* (Southern Pocket Gopher)
  - **Cricetidae** (Mice, Rats, Lemmings, & Voles)
    - *Neotoma* spp. (Woodrat)

AVES (Birds)
- Order Galliformes (Gallinaceous birds, including Quail)

REPTILIA
- Order Testudines
  - **Emydidae** (Box & Water Turtles)
    - *Clemmys marmorata* (Western Pond Turtle)
- Order Squamata
  - Suborder Serpentes (Snakes)

Table 7-2. Fish Taxa

TELEOSTEI			
	Order Scorpaeniformes		
		Scorpaenidae (Scorpionfishes & Rockfishes)	
			cf. *Sebastes* spp. (Rockfish)
	Order Perciformes		
		Carangidae (Jacks, Amberjacks, Pompanos)	
			cf. *Seriola lalandi* (Yellowtail)
		Clinidae (Kelpfish, Fringeheads)	
		Embiotocidae (Surfperch)	
		Labridae (Wrasses)	
			Semicossyphus pulcher (California Sheephead)
		Sciaenidae (Croakers)	
		Scombridae (Mackerels & Tunas)	
			Sarda chiliensis (Pacific Bonito)
			Scomber japonicus (Pacific Mackerel)
		Serranidae (Sea Basses & Groupers)	
			Paralabrax spp. (Bass)
		Sphyraenidae (Barracudas)	
			cf. *Sphyraena argentea* (California Barracuda)
	Order Pleuronectiformes		
		Bothidae (Lefteye Flounders)	
			Paralichthys californicus (California Halibut)
ELASMOBRANCHII			
	Order Carcharhiniformes		
		Scyliorhinidae (Cat Sharks)	
			cf. *Cephaloscyllium ventriosum* (Swell Shark)
		Triakididae (Smoothhounds)	
			Galeorhinus galeus (Soupfin Shark)
	Order Rhinobatiformes		
		Rhinobatidae (Guitarfishes)	
			Rhinobatos productus (Shovelnose Guitarfish)
	Order Myliobatidiformes		
		Myliobatididae (Eagle Rays)	
			Myliobatis californica (Bat Ray)

Table 7-3. Density of Vertebrate Remains Based on the Analytic Units from CA-SDI-811

AU	*Volume Excavated (m^3)*	*Non-fish 1/4" from Units*	*Non-fish 1/4" from Column*	*Non-fish 1/8" from Column*	*Non-fish Sub-total*	*Fish Sub-total*[1]	*Total NISP*[2]	*Density (NISP/m^3)*[2]
AU 1	1.4	107	1	85	193	43	236	168.6
AU 2	0.6	29	3	76	108	33	141	235.0
AU 3	0.6	88	5	71	164	163	327	545.0
AU 4	1.2	237	3	117	357	51	408	340.0
AU 5	0.6	141	12	74	227	116	343	571.7
Total	4.4	602	24	423	1,049	406	1,455	330.7

[1] Fish sub-total from units (1/4") and column samples (1/4" & 1/8").
[2] NISP = Number of individual specimens present.

Subsistence and Settlement

The overall impression for SDI-811, based on the vertebrate remains, is one of a generalized or diversified subsistence strategy that used a wide range of resources from the region immediately adjacent to the site. As measured by bone weight, there is a significant difference in the ranking of large mammals, small mammals, and fish, with large mammals ranking first, followed by fish and small mammals. The limited evidence for season of occupation suggests use of the site between March and October. The vertebrate data would be consistent with either sporadic short-term use during this time span or steady, semi-sedentary use of the coast during this part of the year.

The site assemblage shows a fair amount of diversity for the sample size, including marine (fish, sea otter, pinniped), freshwater (pond turtle), and terrestrial resources (deer, coyote or dog, jackrabbit, cottontail or brush rabbit, ground squirrel, pocket gopher, woodrat) (Table 7-4).

The list of species identified compares well with that from a sample analyzed in 1996 (Hudson et al. 1996). A few additional species were noted in the present analysis, including pinniped, pond turtle, and possible yellowtail.

Both large and small terrestrial game, consisting primarily of deer and rabbit, are common throughout the site. This is a pattern seen at many coastal sites in northern San Diego County. It suggests that people occupying the coast maintained a strong tie to inland resources. Both deer and rabbit would have been available along the coastal strip and in the hills, canyons, and valleys located immediately inland. Their importance at a coastal site suggests that the site was a residential one, rather than a station used briefly to extract the immediately abundant coastal resources of shellfish and fish. Deer and rabbit hunting can be done by single individuals or by small groups. In southern California, deer hunting techniques included snares, and stalk and ambush, sometimes with deer-head disguises. Rabbit hunting techniques included snares and throwing sticks. Rabbits can also be hunted by large groups in cooperative drives, although this strategy is more common with

Table 7-4. Taxa for CA-SDI-811

	Units (1/4")		Column Samples (1/4")		Column Samples (1/8")		Total	
Taxon	*NISP*	*Wt (g)*	*NISP*	*Wt (g)*	*NISP*	*Wt (g)*	*NISP*	*Wt (g)*
Marine Resources								
Fish	575	169.78	48	9.48	530	16.39	1,153	195.65
Otariid	2	8.48	-	-	-	-	2	8.48
Pinniped	12	26.62	-	-	-	-	12	26.62
Sea Otter	10	8.77	-	-	-	-	10	8.77
Marine Mammal, undif.	17	17.21	-	-	-	-	17	17.21
Terrestrial Resources								
Deer	33	116.28	1	2.19	1	0.04	35	118.51
Artiodactyl, undif.	5	8.27	-	-	-	-	5	8.27
Large Mammal	130	148.89	13	11.92	-	-	143	160.81
Coyote or Dog	19	37.86	-	-	-	-	19	37.86
Carnivore, undif.	7	2.71	-	-	1	0.19	8	2.90
Medium Mammal	43	22.38	2	0.33	5	0.58	50	23.29
Medium-Large Mammal	253	119.37	13	6.96	11	1.38	277	127.71
Jackrabbit	40	10.92	3	0.74	4	0.27	47	11.93
Cottontail/Brush Rabbit	89	22.46	7	1.64	15	1.03	111	25.13
Leporid, undif.	5	1.31	1	0.32	-	-	6	1.63
Ground Squirrel	23	7.57	-	-	-	-	23	7.57
Sciurid, undif.	1	0.21	-	-	-	-	1	0.21
Pocket Gopher	26	7.33	3	0.31	1	0.02	30	7.66
Woodrat	3	0.35	-	-	-	-	3	0.35
Rodent	4	0.49	-	-	2	0.07	6	0.56
Small Mammal	159	22.53	16	1.96	364	14.46	539	38.95
Small-Medium Mammal	64	17.02	6	1.17	13	1.17	83	19.36
Mammal, undif.	4	0.61	-	-	3	0.14	7	0.75
Snake	3	0.37	-	-	6	0.16	9	0.53
Reptile, undif.	-	-	-	-	5	0.10	5	0.10
Freshwater Resources								
Pond turtle	15	4.20	2	0.45	2	0.16	19	4.81
Bird	39	9.72	1	0.21	5	0.30	45	10.23
Vertebrate, undif.	493	100.22	27	6.84	898	28.56	1,418	135.62
Total	2,074	891.93	143	44.52	1,847	64.85	4,064	1,001.30

jackrabbits in arid, open environments. The rabbit bone identified at SDI-811 is a mix of jackrabbit and the smaller rabbits, brush rabbit and cottontail, and the coastal strip and adjacent hills would have been less optimal an environment for drives; it is more likely that rabbit hunting at SDI-811 was carried out by individuals or small groups.

Fish remains are present throughout the site. The total assemblage of analyzed fish consisted of 1,153 fragments weighing a total of 195.65 grams. A wide variety of fish remains from various habitat settings are represented. Quantitative data are presented in Table 7-5; habitat associations follow Bowser (1996), de Martini (1969), Eschmeyer et al. (1983), and U.S. Department of the Interior (MMS 1987). Sheephead, bass, kelpfish, and rockfish can be found along shallow rocky bottoms, including rocky intertidal and nearshore

kelp beds. Small flatfish, bat ray, and shovelnose guitarfish swim along sandy bottoms, including open bays, marine estuaries, open sandy beaches, and nearshore soft bottom areas. Croakers, surfperch, and smoothhound sharks live in undifferentiated nearshore waters. Halibut can be found along cold sandy bottoms, including both offshore and nearshore waters. Pacific mackerel school in pelagic, open waters and often stay close to nearshore kelp beds. Barracuda and bonito also prefer open, nearshore surface waters, but move to more offshore waters during the fall.

Table 7-5. Fish Assemblage from CA-SDI-811

		Units		Column Samples		Total	
Taxon	*Habitat*[1]	*NISP (ct)*	*Weight (g)*	*NISP (ct)*	*Weight (g)*	*NISP (ct)*	*Weight (g)*
Teleostei							
Teleostei, undif.	V	355	81.19	454	17.51	809	98.70
Carangidae	V	1	1.20	-	-	1	1.20
cf. Clinidae	SR	-	-	1	0.01	1	0.01
Embiotocidae	NS	1	0.17	-	-	1	0.17
Semicossyphus pulcher	SR	43	17.58	7	1.11	50	18.69
Sciaenidae	NS	9	4.15	50	2.10	59	6.25
Scombridae	OP	1	0.14	-	-	1	0.14
Sarda chiliensis	OP	1	0.26	-	-	1	0.26
Scomber japonicus	OP	11	1.30	23	1.09	34	2.39
Paralabrax spp.	SR	10	2.41	10	0.79	20	3.20
cf. *Sphyraena argentea*	OP	2	0.85	-	-	2	0.85
Pleuronectiformes	SS	1	0.85	2	0.04	3	0.89
Bothidae	SB	8	7.49	-	-	8	7.49
Elasmobranchii							
Elasmobranchii, undif.	V	56	10.83	14	0.70	70	11.53
Triakididae	NS	12	6.40	-	-	12	6.40
Galeorhinus galeus	NS	9	20.06	1	1.19	10	21.25
Rhinobatiformes/ Myliobatidiformes	V	7	2.10	1	0.04	8	2.14
Rhinobatos productus	SS	27	8.39	2	0.31	29	8.70
Myliobatidiformes	V	11	1.71	3	0.24	14	1.95
Myliobatis californica	SS	9	2.60	8	0.70	17	3.30
Fish, undif.	V	1	0.10	2	0.04	3	0.14
Total	-	575	169.78	578	25.87	1,153	195.65

1 Habitat: SR = shallow rocky bottom, SS = shallow sandy bottom, NS = undifferentiated nearshore, SB = cold sandy bottom, OP = open surface waters, V = various

The relative importance of the various fish habitats is presented in Table 7-6. The total count of fish bone for taxa assigned to a specific habitat setting (excluding undifferentiated Teleost, undifferentiated Elasmobranch, and undifferentiated fish) were added together and a percentage value was derived by dividing the counts per habitat by the total count. No single habitat appears to dominate. Instead, fish from sandy bottom, rocky bottom, and even open water habitats are fairly evenly distributed. This pattern reinforces the impression of residential occupation rather than brief visits focused on extracting resources from a very limited area. The occupants appear to have used the full range of habitats available to them locally.

Table 7-6. Relative Importance of Different Fish Habitats

Habitat[1]	*NISP*	*% of Total NISP*
Shallow rocky bottoms (SR)	71	26.20
Shallow sandy bottoms(SS)	49	18.08
Cold sandy bottoms (SB)	8	2.95
Nearshore, undifferentiated (NS)	82	30.26
Open surface waters (OP)	38	14.02
Various (V)	23	8.49

[1]NISP and percentages exclude undif. fish, undif. Teleost, and undif. Elasmobranch.

The majority of the fish represented could have been caught with hook and line technology, especially the carnivorous fish such as yellowtail, sheephead, rockfish, bass, bonito, mackerel, and halibut. Some of the smaller rays may have been captured by hand (Bowser 1996). Ethnohistorical data demonstrate that the Luiseño utilized bone and shell fishhooks and yucca fishing line (McCawley 1995) and nets (Iovin 1963). These implements would have been effective for catching most of the species represented by this collection. In addition, coastal groups used dugout and/or bundled rush canoes (Earle and O'Neil 1994; Harrington 1986; McCawley 1995), which would have allowed the inhabitants access to offshore fishing grounds.

Marine mammals are present but not abundant at the site. The presence of two sea otter atlas vertebra suggests the possibility that otters were skinned at the site. The atlas vertebra connects directly with the skull, and is most likely to be lost or removed when the skull is disarticulated from the rest of the body. As noted in the Background section above, otter skins were prized by Native Californians. In prehistoric times, prior to the incursion of Russian and Aleut fur-traders into southern California, sea otter would have been available locally. Sea otters would have been present year-round and probably easiest to catch in the kelp beds, using some type of boat. The analysis of the fish remains notes the presence of several fish in the assemblage that are also common in kelp beds, including sheephead, bass, kelpfish, and rockfish. Modern fishing maps show kelp beds offshore near the site and list many of the same species at that locale.

Season of Occupation

Evidence for season of occupation is limited. Rasmussen notes that most of the fish represented in the current sample were species that could be caught year-round. Bowser (1996) has suggested that barracuda and other taxa represented in a previous sample from the site would be consistent with a spring to fall occupation. Huddleston's (1996) analysis of otoliths from a previous sample suggests occupation from March to October.

The presence of juvenile deer bone suggests occupation in the fall or early winter. The evidence consists of an unfused distal metapodial from AU 4. Deer are typically born in May or June and this point of fusion usually occurs after 27 months in regions with good forage, or as late as 30 months in regions of poor forage (Gilbert 1980). This would yield an approximate kill season between August and December, with an August/September hunt more likely if forage conditions are assumed to have been good.

The presence of pinniped remains may represent summer occupation if such hunting was focussed during the season when fur seals and sea lions were on land in rookeries and easier to kill. Local pinnipeds, such as the California sea lion and the Guadalupe fur seal, would be most easily hunted on land when congregated in nurseries. For the local species, this occurs primarily during the summer, from mid-May to late June for the sea lion and from June to July for the fur seal (Riedman 1990).

The combined evidence correlates well with spring, summer, and fall use of the site. However, the samples are very small, and lack of specific evidence for winter occupation does not preclude site use during that season as well. Most of the fish could be caught year-round, as could pinnipeds if exploited in non-rookery situations.

7.6 INTRA-SITE PATTERNING AND TEMPORAL CHANGE

Five analytic units were established based on patterning in the spatial distribution of remains at the site, as explained in Chapter 5. They appear to represent both temporal and functional differences in occupation areas within the site. The faunal remains show some patterning in terms of density of remains, percentage of burned bone, and emphasis on certain categories of fauna (Tables 7-7 and 7-8). A breakdown of the vertebrate taxa per analytic unit is provided in Table 7-9, and the fish taxa are further separated in Table 7-10. The distribution of animal types (i.e., fish, marine mammal, small mammal, medium mammal, and large mammal) represented in each analytic unit, based on the percent contribution by bone weight, is provided in Figure 7-1.

Table 7-7. Summary Data per Analytic Unit for Vertebrate Remains from CA-SDI-811

	AU 1	*AU 2*	*AU 3*	*AU 4*	*AU 5*
Sample size (NISP)	236	141	327	408	343
Number of Mutually-Exclusive Taxa (RICHNESS)	12	10	13	14	16
Density (NISP/m³)	168.6	235.0	545.0	340.0	571.7
Percent Fish (NISP)	18.2%	23.4	49.8%	12.5%	33.8%
Percent Burned (NISP)	16.9%	48.2%	26.9%	21.3%	20.4%

Note: All quantitative data refer to combined unit and column samples, fish and non-fish, for the analytic unit.

Two of the analytic units, AU 4 and AU 5, fall temporally within the latter part of the Late Archaic and exhibit high densities of fire-altered rock, currently interpreted as hearth-cleaning dumps. Both have relatively high densities of bone. AU 5 has the highest bone density, approximately 571.7 fragments per cubic meter. Both have moderate richness of taxa. The richness may be linked to sample size, as these two analytic units also have the largest NISP values. Both units show mixed use of marine and terrestrial resources. Fish taxa represented include sheephead, croaker, shovelnose guitarfish, and bat ray in AU 4, and surfperch, croaker, bass, sheephead, a small flatfish, soupfin shark, and bat rat in AU 5. AU 5 has the second highest density of fish (NISP per cubic meter) of the analytic units. The percentage of bone showing signs of burning is similar to that throughout most of the site, 20 to 22 percent by count.

Table 7-8. Summary Data per Analytic Unit for Fish Remains from CA-SDI-811

	AU 1	*AU 2*	*AU 3*	*AU 4*	*AU 5*
Volume Excavated (m^3)	1.4	0.6	0.6	1.2	0.6
Sample size (NISP)	43	33	163	51	116
Number of Mutually-Exclusive Taxa (RICHNESS)	4	4	8	4	7
Density (NISP/m^3)	30.7	55.0	271.7	42.5	193.3
Weight (g)	2.74	1.88	46.27	8.85	22.11
Density (g/m^3)	2.0	3.1	77.1	7.4	36.9

AU 3 has been dated to AD 70 (calibrated intercept), which places it in the Late Prehistoric, perhaps representing the beginning of the influx of Shoshonean peoples. Vertebrate remains show a mix of terrestrial resources, including both small and large game, and the highest percentage of fish by NISP of any of the analytic units (49.8 percent), but no evidence of the use of marine mammals. Richness of taxa is moderate for terrestrial vertebrates, but high for fish. AU 3 has the highest density of fish (NISP per cubic meter) of any of the analytic units. Fish taxa represented include sheephead, croaker, mackerel, bass, flounder, soupfin shark, shovelnose guitarfish, and bat ray.

AU 2 represents a later occupation in the same part of the site as AU 3. It is the smallest of the vertebrate samples and has correspondingly low richness, but all size classes of terrestrial mammals are represented as well as four distinct species of fish. Fish taxa include pacific mackerel, croaker, shovelnose guitarfish, and bat ray. AU 2 stands out among the five analytic units for its relatively high frequency of burned bone; roughly 50 percent of the fragments are burned, nearly double the percentage from any other unit.

AU 1 has been dated to A.D. 710-905 (1-sigma calibrated range), which places it in the Late Prehistoric period. Despite its small sample size, it shows a relatively high richness of taxa, including pinniped, turtle, four distinct types of fish as well as large, medium, and small terrestrial mammals. Fish taxa include sheephead, bass, croaker, and smoothhound shark. This analytic unit yielded the highest density of shellfish and the lowest density of bone. This is the only analytic unit that produced worked bone, consisting of one possibly incised bone fragment (Catalog # 77) and one possible awl fragment (Catalog # 77).

Different parts of the site appear to have been used at different times, and perhaps for different purposes. Marine mammal exploitation, including the hunting of sea otters, appears to have been more important in the Late Archaic, and appears to have been part of a mixed strategy of fishing and hunting, with use of large and small terrestrial game as well. The Late Prehistoric period occupations show similar mixed emphasis on large and small terrestrial game, and perhaps a shift away from marine mammals accompanied by greater emphasis on either fish, as seen in AU 3, or shellfish, as seen in AU 1. AU 2 is distinctive for its higher percentage of burned bone, but its taxonomic composition is similar to the other units, allowing for the lower richness expected with its smaller sample size.

Table 7-9. Vertebrate Taxa per Analytic Unit for CA-SDI-811

	AU 1		AU 2		AU 3		AU 4		AU 5	
Taxon	*NISP*	*Wt (g)*	*NISP*	*Wt (g)*	*NISP*	*Wt (g)*	*NISP*	*Wt (g)*	*NISP*	*Wt (g)*
Marine Resources										
Fish	43	2.74	33	1.88	163	46.27	51	8.85	116	22.11
Pinniped	1	1.48	-	-	-	-	1	1.84	2	17.93
Sea Otter	-	-	-	-	-	-	1	0.22	-	-
Marine Mammal, undif.	-	-	-	-	-	-	3	2.24	-	-
Terrestrial Resources										
Deer	-	-	-	-	1	2.79	3	23.05	1	3.51
Artiodactyl, undif.	1	0.46	-	-	-	-	3	4.36	-	-
Large Mammal, undif.	11	6.96	-	-	6	9.11	25	33.73	23	23.06
Coyote or Dog	15	8.12	-	-	-	-	2	17.86	-	-
Carnivore, undif.	-	-	-	-	-	-	4	2.04	-	-
Medium Mammal, undif.	3	2.14	3	1.18	-	-	6	2.21	8	4.45
Medium-Large Mammal, undif.	16	7.25	8	3.67	7	8.93	50	20.84	23	9.45
Jackrabbit	3	0.50	2	0.36	-	-	11	1.95	2	0.65
Cottontail or Brush Rabbit	4	0.77	1	0.05	-	-	11	1.81	6	1.79
Leporid, undif.	2	0.33	-	-	-	-	-	-	1	0.32
Ground Squirrel	-	-	1	0.27	-	-	-	-	1	0.38
Sciurid, undif.	-	-	-	-	1	0.21	-	-	-	-
Pocket Gopher	2	0.71	-	-	5	2.63	-	-	1	0.11
Woodrat	1	0.16	-	-	-	-	-	-	-	-
Rodent, undif.	3	0.10	-	-	-	-	1	0.27	-	-
Small Mammal, undif.	40	2.83	13	0.74	26	2.70	62	4.82	25	1.61
Small-Medium Mammal, undif.	4	1.13	4	0.16	1	0.03	9	2.46	4	0.89
Mammal, undif.	-	-	-	-	-	-	-	-	1	0.08
Snake	-	-	2	0.13	1	0.02	-	-	-	-
Reptile, undif.	-	-	-	-	-	-	1	0.04	-	-
Freshwater Resources										
Pond turtle	1	0.23	-	-	1	0.37	6	1.97	2	0.52
Bird	-	-	1	0.03	-	-	5	1.12	7	1.58
Vertebrate, undif.	86	6.13	73	4.98	115	14.95	153	21.35	120	14.88
Total	236	42.04	141	13.45	327	88.01	408	153.03	343	103.32

Note: *All quantitative data refer to combined unit and column samples for the analytic unit.*

Table 7-10. Fish Taxa per Analytic Unit for CA-SDI-811

	AU 1		AU 2		AU 3		AU 4		AU 5	
Taxon	*NISP*	*Wt (g)*	*NISP*	*Wt (g)*	*NISP*	*Wt (g)*	*NISP*	*Wt (g)*	*NISP*	*Wt (g)*
Teleostei										
Undif. Teleostei	33	1.39	25	1.08	122	23.29	29	5.02	80	9.31
Embiotocidae	-	-	-	-	-	-	-	-	1	0.17
Semicossyphus pulcher	2	0.43	-	-	1	0.17	2	0.74	7	4.81
Sciaenidae	4	0.17	1	0.03	3	0.14	1	0.04	8	1.71
Scombridae	-	-	-	-	1	0.14	-	-	-	-
Scomber japonicus	-	-	4	0.11	11	0.94	-	-	-	-
Paralabrax spp.	1	0.18	-	-	3	0.86	-	-	3	0.34
Pleuronectiformes	-	-	-	-	1	0.85	-	-	1	0.02
Bothidae	-	-	-	-	3	4.74	-	-	-	-
Elasmobranchii										
Undif. Elasmobranchii	-	-	-	-	4	1.15	15	1.94	9	2.59
Triakididae	2	0.55	-	-	-	-	-	-	2	0.61
Galeorhinus galeus	-	-	-	-	3	11.08	-	-	1	1.84
Rhinobatiformes/Myliobatidiformes	-	-	-	-	3	1.24	-	-	-	-
Rhinobatos productus	-	-	1	0.16	4	1.41	2	0.36	-	-
Myliobatidiformes	-	-	-	-	2	0.13	-	-	-	-
Myliobatis californica	-	-	2	0.50	2	0.13	2	0.75	4	0.71
Fish, undif.	1	0.02	-	-	-	-	-	-	-	-
Total	43	2.74	33	1.88	163	46.27	51	8.85	116	22.11

Note: *All quantitative data refer to combined unit and column samples for the analytic unit.*

7.7 BONE MODIFICATION

Evidence of cultural modification of bone was fairly limited. It includes burning, butchering marks, and modification as a tool or ornament.

Burned bone often represents cooking or discard behavior. Burned bone appeared fairly evenly distributed among the analytic units with the exception of a concentration of burned bone in AU 2. Site wide, the percentage of burned bone ranged between 16 and 27, except in AU 2 where it reached 48. Both large and small game were burned, with some suggestion of patterned burning on certain rabbit elements, including parts of the cranium that would be likely to be scorched if the animal was roasted whole. None of the identified rodent bone was burned; it may represent non-cultural deposition. Of the 1,153 fish fragments analyzed, approximately 17 percent showed obvious signs of charring or calcination.

Butchering marks were not abundant, but were noted occasionally on mammal bone, including marks on medium-large vertebrae consistent with removal of the meat along the spine. No evidence of butchering was observed on the fish bone.

Twelve items of possibly worked bone were identified at the site. Three of these clearly appear modified, but the others are less certain and include possible manufacturing by-products. One bird bone bead (Catalog # 1181; Figure 7-2) was recovered from below AU 1 in Unit 100 (90-100 cm). The bead showed evidence of being cut and snapped at both ends, but lacked signs of further finishing. It was made from the limb bone of a medium to large bird. It is approximately 1 cm long and 0.5 cm in diameter, and lacks any distinguishing surface features. Other worked items included one very finely made awl with a diameter of 3.8 mm (Catalog # 1751), one small large mammal fragment with a possible abraded surface (Catalog # 52), a tapering cylinder that may have been part of an awl (Catalog # 77), a possibly incised mammal shaft fragment (Catalog # 77), one fragment which appears to show lashing wear (Catalog # 1652), one small fragment with parallel grooves which may represent an incised ornament or tool (Catalog # 1684), a large mammal shaft fragment that may have been a possible tool or by-product (Catalog # 7), and four deer metapodial fragments which appear to represent tool preforms or discarded by-products (Catalog #'s 57, 80, 96, 111). AU 1 represents the last of the dated occupations of the site and is the only analytic unit that provides direct evidence for the use or manufacture of bone artifacts (two items from Catalog # 77). The general lack of worked items in the four older analytic units may argue against long-term residential use of the site during those periods, or may simply represent differences in the activity areas being sampled.

7.8 INTER-SITE COMPARISONS

Three sites were chosen for comparison with SDI-811, based on similarities in location and occupation dates, and availability of comparable faunal data. These are SDI-13325, -4538, and -10726 (see Figure 1-6 and 1-7). SDI-13325 is located roughly 15 kilometers to the north near the mouth of San Onofre Creek and has occupation dates similar in range to those of SDI-811. SDI-4538 is located near the coast at Horno Canyon, approximately five kilometers to the north. SDI-10726 is located on the opposite side of Las Flores Creek, immediately south of SDI-811. Both SDI-4538 and SDI-10726 were roughly contemporaneous with the latter part of the occupation at SDI-811.

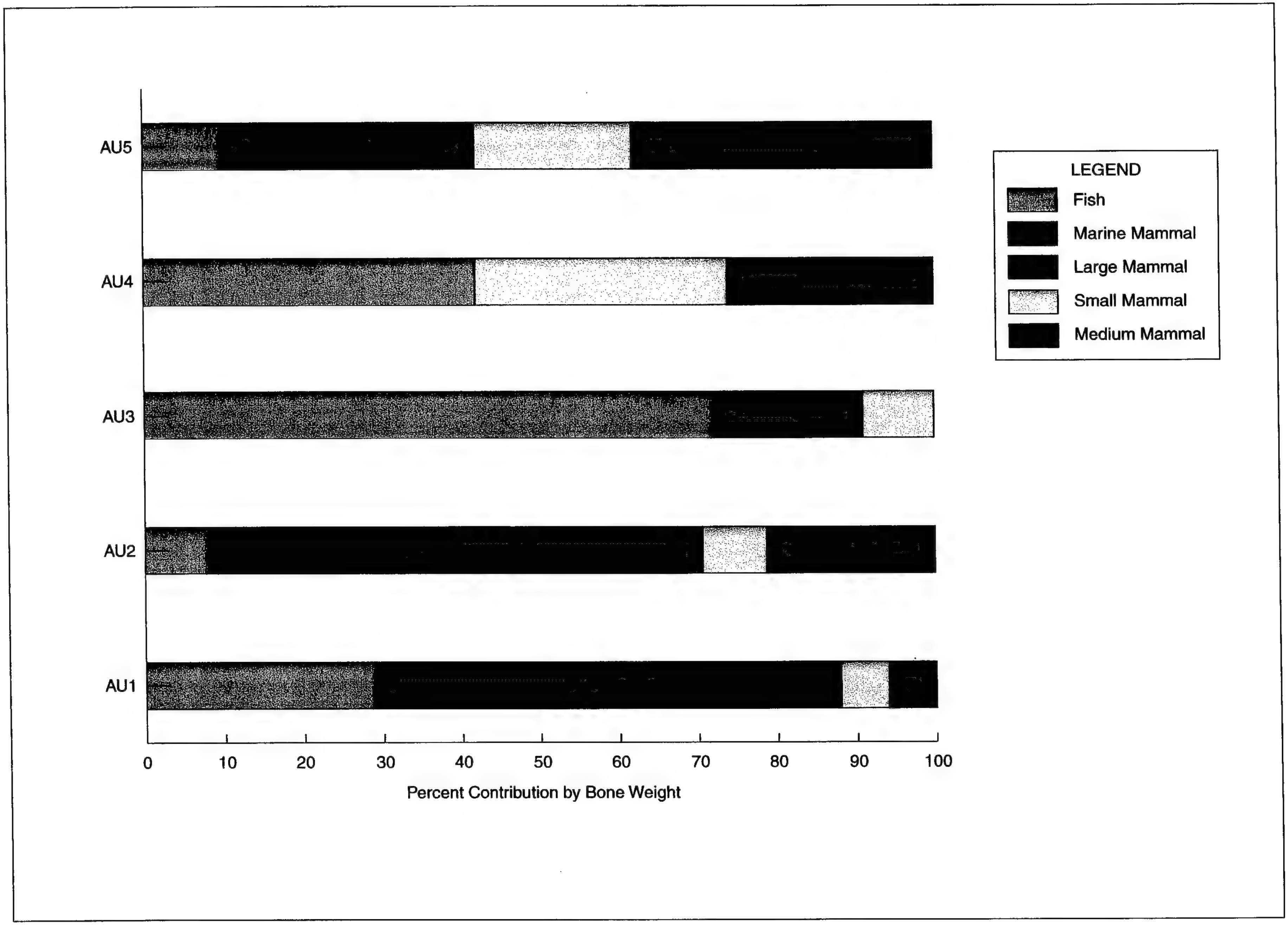


Figure 7-1. Distribution of Animal Types by Analytic Unit

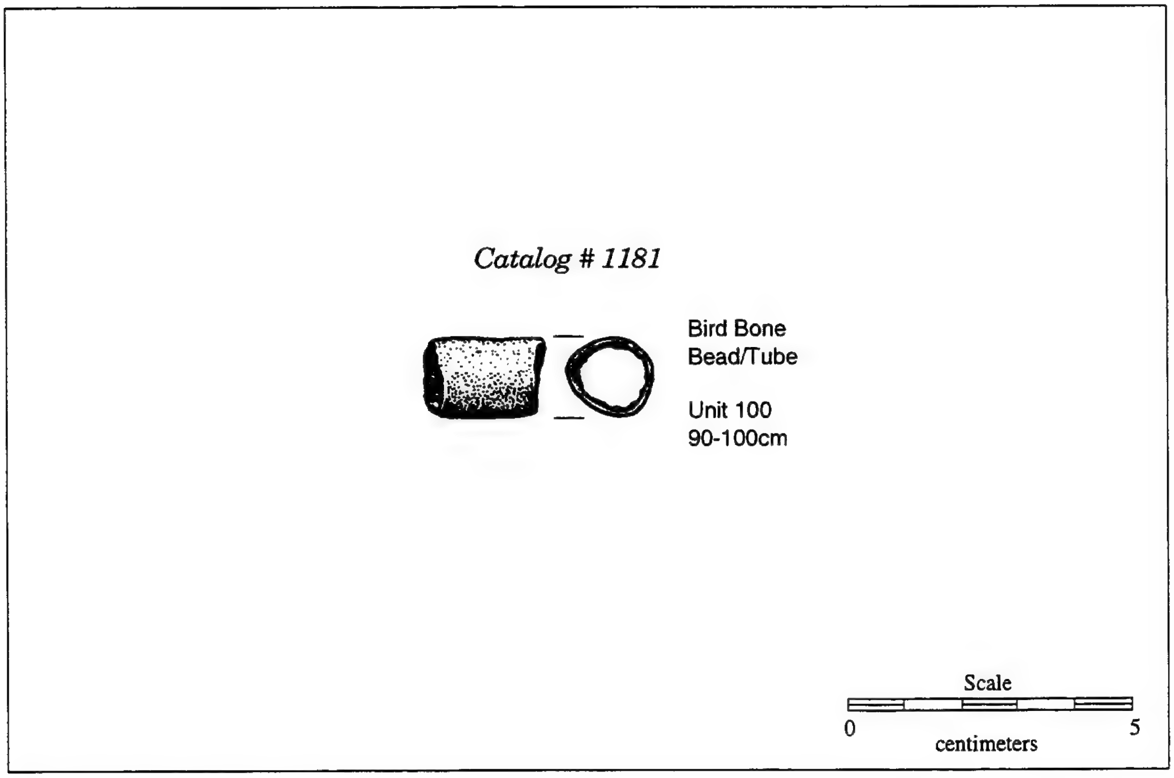


Figure 7-2. Bone Artifact from SDI-811

SDI-811 is most like SDI-13325 in the presence of worked bone, the presence of sea otter, and spatial complexity (Table 7-11). SDI-13325 shows a greater richness of taxa. SDI-811 falls between its closer neighbors, SDI-4538 and -10726, in terms of overall bone density, although all exhibit a similar richness of taxa. Richness differences may be due in part to the differences in sample size. SDI-811 appears to reflect the greatest emphasis on fish, compared to the other sites; approximately half the fish, by count, comes from the 1/8" column samples.

Table 7-11. Comparison of Vertebrate Assemblages from Camp Pendleton Sites (Late Archaic to Late Prehistoric)

Site	*NISP*	*NISP/m*^{3}	*Richness*	*Fish*[1]	*Otter*	*Pinniped*	*Deer*	*Rabbit*[3]	*Worked Bone*
SDI-13325	3,704	N/A	35	17%	yes	yes	yes	yes	yes
SDI-811	4,064	198	27	28%	yes	yes	yes	yes	yes
SDI-4538	289	137	21	22%	no	yes	yes	yes	no
SDI-10726	728	277	27	20%	no	yes	?[2]	yes	no

Notes: Data based on 1/8" or greater mesh recovery; field and lab techniques varied and may influence results.

1. Percent fish based on fish NISP/total NISP.
2. Large terrestrial mammal was present, but identification at species level was not possible.
3. Rabbit used here as a shorthand for leporid, which includes both *Lepus* and *Sylvilagus*.

The greater use of marine mammals at SDI-13325 and the earlier components of SDI-811 may represent a temporal shift in subsistence strategies. The basic pattern of a mixed strategy remains the same throughout, although the ranking of fish, marine mammal, and large and small terrestrial game varies. AU 4 and AU 5, representing the Late Archaic, show fish, marine mammal and large terrestrial mammal to be important, with a relatively equal ranking in AU 5 and a stronger focus on large terrestrial in AU 4. AU 3 shows a strong shift to fish. AU 2 balances fish, small terrestrial mammals, and medium terrestrial mammals. AU 1 shows a strong emphasis on terrestrial mammals. Given the small sample sizes, interpretations should be considered tentative. As always, alternative hypotheses should be entertained; differences may represent spatial variation in activity location as readily as temporal change.

7.9 SUMMARY

Based on the vertebrate remains from SDI-811, the introductory research questions discussed in the beginning of the chapter can be addressed. The density of bone, the diversity of taxa, the range of local habitats exploited, the spatial patterning of remains, and the seasonal evidence are consistent with short-term residential use during spring, summer, and fall. Sporadic year-round use is also possible.

Resource habitats utilized include marine and terrestrial, with evidence for the use of nearshore, offshore, open waters, rocky and sandy bottoms, kelp beds, the coastal strip, and nearby hills and creeks.

Activities carried out at the site include hunting of deer, rabbit, sea otter, and pinniped, fishing, probably with hook and line and nets, from the shore and from boats, skinning and butchering, cooking, consumption, and discard. Certain activities appear both spatially and temporally discrete. These include the association of sea otter remains with the Archaic component in AU 4, a concentration of fish remains in the early Late Prehistoric component in AU 3 (Figure 7-1), and a concentration of burned bone in the somewhat later Late Prehistoric component in AU 2.

Evidence for non-food use of vertebrates at the site consists of a single bird bone bead, a finely worked awl, a possible awl fragment, and several possibly worked items showing abrasion, incisions, or lashing marks. It is likely that sea otter, deer, and rabbit were valued for their skins as well as their meat.

A general pattern of mixed resource use (Figure 7-1) is consistent throughout the occupation period. This resource mix includes fish, large game, and small game, although the percentage of the different animal types changes through time. For example, there is some indication that marine mammals were more important in the Late Archaic, while fish became more important during the Late Prehistoric.

8 INVERTEBRATE FAUNAL ANALYSIS

Karen A. Rasmussen

8.1 INTRODUCTION

This chapter describes the analysis of the invertebrate faunal assemblage from SDI-811. The analytical methods were designed to provide information suitable for addressing the research questions presented in Chapter 3, especially those centered on defining food processing activities at the site and how they changed over time. This chapter begins by providing general information on the site assemblage as a whole, including species represented and habitats exploited. Second, an intra-site analysis is conducted by comparing the site's five analytical units in terms of the distribution, density, and diversity of shellfish species. Finally, the Red Beach assemblage is compared to nine other sites on Camp Pendleton in order to examine regional variability in resource exploitation.

8.2 MATERIAL AND METHODS

Cultural material was dry-screened in the field and size-sorted into 1/4" and 1/8" categories. The material was then water-screened and sorted into general categories, such as bone, shell, and flaked stone. After the cataloging procedures were completed, the shellfish was set aside for further analysis.

All of the invertebrate remains recovered from the 1/4" screens of the 24 test excavation units were identified to the most specific taxonomic level possible. Weights, MNI (minimum number of individuals), burning, and signs of modification were noted and recorded. The material smaller than the 1/4" screen mesh were not identified because it would bias the sample toward those shell species whose tiny fragments are easily identified (e.g., *Donax gouldii*), while it would not greatly change the MNI counts for any of the shellfish species. The detailed invertebrate catalog is provided in Appendix D.

Identifications were based on invertebrate comparative collections housed at the Santa Barbara office of SAIC as well as those belonging to the Department of Anthropology, University of California, Santa Barbara. Taxonomic designations were based, for the most part, on Morris (1980). Most of the shellfish remains were identified to at least the genus level; however, there were a few exceptions. Chitons and crabs were identified only to a very general level because the comparative collections were not complete enough to allow for more specific identifications. Some of the invertebrate remains were simply designated as Veneridae (clam), Pectinidae (scallop), undifferentiated Gastropod (univalve), or undifferentiated shell when the shell fragments were either too fragmentary or too weathered for a more specific identification. Identified taxa are listed in Table 8-1.

Table 8-1. Invertebrate Taxa

PHYLUM MOLLUSCA
- Class Gastropoda
  - **Calyptraeidae** (Cup-and-Saucer Limpets & Slipper Shells)
    - *Crepidula* spp. (Slipper Shell)
  - **Eratoidae** (Sea Buttons)
    - *Trivia* spp. (Coffee Bean/Sea Button)
  - **Haliotidae** (Abalones)
    - *Haliotis* spp. (abalone)
  - **Olividae** (Olive Shells)
    - *Olivella biplicata* (Purple Olive)
  - **Trochidae** (Pearly Top Shells)
    - *Tegula* spp. (Top Shell)
- Class Pelecypoda
  - **Chamidae** (Jewel Box)
    - *Pseudochama exogyra* (Reversed Jewel Box)
  - **Donacidae** (Bean Clams)
    - *Donax gouldii* (Little Bean Clam)
  - **Mactridae** (Surf Clam)
    - *Tresus nuttallii* (Gaper Clam)
  - **Mytilidae** (Mussels)
    - *Mytilus californianus* (California Mussel)
    - *Septifer bifurcatus* (Platform Mussel)
  - **Ostreidae** (Oysters)
    - *Ostrea lurida* (California Oyster)
  - **Pectinidae** (Scallops)
  - **Sanguinolariidae** (Gari Shells)
    - *Tagelus californianus* (Jackknife Clam)
  - **Veneridae** (Venus Clams)
    - *Chione* spp. (Venus)
    - *Protothaca* spp. (Littleneck)
    - *Tivela stultorum* (Pismo Clam)
- Class Polyplacophora (Chiton)

PHYLUM ARTHROPODA
- Subphylum Crustacea
  - **Order Decapoda** (crab)
  - **Balanidae**
    - *Balanus* spp. (barnacle)

MNI values were calculated for the site, as a whole, as well as for the individual analytical units. Calculations were based on the number of apices or columns present for the gastropods, the higher number of left and right valves for the pelecypods, and the number of chiton plates divided by eight. No MNI determinations were made for the crustaceans (e.g., crab and barnacles). Weights were recorded to the nearest 0.01 gram.

8.3 RESULTS

The analyzed invertebrate collection contains an estimated MNI of 5,074 with a total weight of 5,733.36 grams (Table 8-2). The collection contains a wide variety of shellfish species, including Gastropods from 5 different families and Pelecypods from 7 families. In addition, the collection includes the remains of a Polyplacophora (chiton) and at least two types of crustaceans (i.e., crab and barnacle).

Table 8-2. Invertebrate Assemblage from CA-SDI-811

Taxon	*Habitat*[1]	*Tidal Range*[2]	*Faunal Type*[3]	*Weight (g)*	*Weight (%)*	*MNI (ct)*	*MNI (%)*
Gastropoda							
Gastropod, undif.	V	—	—	3.06	0.053	—	—
Crepidula spp.	R/B	B	E	0.25	0.004	1	0.02
Haliotis spp.	R	B	E	9.79	0.171	1	0.02
Olivella biplicata	N/B/E	L	E	0.21	0.004	1	0.02
Tegula spp.	R	L	E	3.90	0.068	1	0.02
Trivia spp.	R	L	E	0.16	0.003	1	0.02
Pelecypoda							
Pelecypod, undif.	V	—	-	—	—	—	—
Chione spp.	B/E	L	I	426.66	7.442	35	0.69
Donax gouldii	N	U	I	3,549.76	61.914	4,872	96.02
Mytilus californianus	R	L	E	30.66	0.535	1	0.02
Ostrea lurida	B/E	L	E	109.19	1.904	38	0.75
Pectinidae	B/E	U	I	512.24	8.934	88	1.73
Protothaca spp.	B/R	L	I	67.00	1.169	8	0.16
Septifer bifurcatus	R/B	L	E	1.20	0.021	1	0.02
Tagelus californianus	B/E	B	I	4.09	0.071	2	0.04
Tivela stultorum	N	B	I	296.15	5.165	21	0.41
cf. *Tresus nuttallii*	B/E	L	I	11.53	0.201	2	0.04
Veneridae	V	—	—	668.86	11.666	—	—
Other Invertebrates							
Chiton, undif.	R	B	E	4.53	0.079	1	0.02
Balanus spp.	R	L	E	1.83	0.032	—	—
Crab, undif.	V	—	E	3.32	0.058	—	—
Shell, undif.	V	—	—	28.97	0.505	—	—
Total	-	—	—	5,733.36	—	5,074	—

[1]Habitat: R = exposed rocky shores; N = exposed nonrocky shores; B = bays; E = estuaries; V = various habitats
[2]Tidal Range: U = upper (includes middle zone); L = lower (includes subtidal zone); B = both upper and lower
[3]Faunal Type: E = epifauna (on rocks or other shells); I = infauna (burrowing)

Although the collection contains a wide diversity of invertebrates, only a select few dominate the collection in terms of percentage of overall weight. *Donax gouldii* compose close to 62 percent of the assemblage (based on weight). The various types of clams (Veneridae family) make up an additional 25 percent of the assemblage. The scallops comprise close to 9 percent of the overall shellfish remains while the oysters make up an additional 2 percent. The other species play only a minor role in the composition of the Red Beach assemblage, ranging from 0.003 percent to 0.535 percent of the entire collection.

The shellfish species originate from a variety of habitat settings. Following Byrd et al. (1995, 1996) and Cerreto (1988), habitats are divided into the four general categories (Table 8-2): (1) exposed rocky shore, which includes shorelines with large rock outcrops in association with mud, sand, cobbles, and/or shell fragments; (2) exposed nonrocky shores, which includes shorelines composed of any of the above substrates, but without large rocky outcrops; (3) bays, which are defined as protected bays composed of any combination of the above habitats; and (4) estuaries, which include marine-dominated estuaries featuring extensive sand and mud flats exposed at low tides. The tidal ranges have been lumped into two general categories consisting of the upper tidal range (uppermost splash zone, upper intertidal, and middle intertidal) and the lower tidal range (lower intertidal and subtidal). The intertidal is exposed during low tides while the subtidal is never exposed to the open air. Note that specific invertebrate animals may thrive in more than one habitat and tidal range.

Bean clams (*Donax gouldii*) are found on sandy marine beaches from the middle intertidal zone to 30 m in depth (Reddy 1996a). This small clam usually can be found in a narrow band within the intertidal zone and is prevalent at Red Beach. Bean clams are subject to population explosions, referred to as resurgent populations, when the number of clams increase to as much as 20,000 per square meter (Reddy 1996a). Although these clams offer only a small food package, they are easy to collect and process. The bean clams could have acted as a dietary supplement to the hunter/gatherer groups living in the area and may even have become a critical staple during resurgent years (see Reddy 1996a for more details about the ecology and behavior of *Donax gouldii*).

The clams come from a variety of habitats. The Venus clam (*Chione* spp.) prefers bay and estuary habitats, the Littleneck clam (*Protothaca* spp.) can be found along bays and rocky shores, and the Pismo clam (*Tivela stultorum*) lives among more sandy substrates. In addition, most of the scallops and oysters could be collected from bays and estuaries.

Overall, the shellfish assemblage indicates a pronounced emphasis on the exploitation of sandy shores, bays, and marine estuaries. Although some of the exploited species found at SDI-811 come from more rocky shores, such as the majority of the gastropods, chitons, barnacles, and mussels, these compose only a minor percentage of the overall invertebrate assemblage. The emphasis on sandy shore species such as *Donax* is not surprising given the beachside location of the site.

Only a small percentage (0.002 percent) of the assemblage displayed signs of burning. The entire 11.33 grams of burnt shellfish from this collection is composed of Venus clams, undifferentiated Veneridae clams, scallops, undifferentiated shell, oysters, chitons, and bean clams (in that order of abundance). The burnt remains were recovered from seven different units, including Units 117, 109, 116, 100, 121, 122, and 101 (in that order of abundance). Most of the burnt remains came from levels below 70 cm in depth.

8.4 INTRA-SITE ANALYSIS

Vertical Distribution of Invertebrates

The Red Beach site has a complex vertical distribution of invertebrate material. ASM reported a slight trend toward higher frequencies of scallop remains below 60 cm and higher frequencies of *Chione* and *Donax* above 60 cm in Unit 1 of SDI-811 (Serr and Bryd 1996). The *Chione* signature is a little more random when ASM's other units were factored in. The ASM researchers suggested that "larger sample sizes are needed to confirm this minor trend, and if confirmed it could have implications for changes in local ecology (notably the infilling of lagoons in northern San Diego County)" (Serr and Byrd 1996: 213).

Looking at the vertical distribution of the invertebrate remains from the current study (Table 8-3), it is apparent that many of these general trends hold true with the addition of a much larger sample size. Scallops and oysters are more numerous below 50 cm in depth than above. Pismo clams and Littlenecks are much more prevalent above 70 cm in depth while the *Chione* signature is still erratic. Frequency of *Donax* remains drops off dramatically after 70 cm in depth.

It was interesting to note that most of the rocky-shore inhabitants, such as the various gastropods, barnacles, chitons, and mussels, were often relegated to the lower levels of the site. For example, chitons were recovered from between 70-130 cm below the surface, *Crepidula* from 70-90 cm, *Septifer* from 90-100 cm, *Tegula* from 80-110 cm, and *Balanus* from 90-130 cm.

Horizontal and Temporal Distribution of Invertebrates

SDI-811 also has a complex horizontal distribution of cultural material. Shell densities across the site ranged from 0 to 1986.30 g/m^3 (see Table 5-2). In order to study intra-site patterns, five analytical units were defined, each of which represent distinct occupations and/or segregated activity areas of the site. The analytic units are described more fully in Chapter 5.

Density values of the invertebrate remains were constructed for the five analytic units. Density simply represents the number of a chosen value (e.g., NISP, weight, MNI) per excavated cultural volume. Density values are useful for comparing different areas of the site because the various analytic units differ in terms of volume. The construction of density values is a heuristic device to help control for sample size differences, which may influence the nature of the assemblage.

Higher densities of faunal material as well as artifacts, debris, and features at a site often relate to longer site duration or re-occupation. For example, different density values of invertebrate remains across a site may correlate with longer occupation at specific areas of the site, more repeated occupation, use by larger numbers of people, or the occurrence of activities that produce more shellfish debris (Woodman et al. 1991).

Table 8-3. Vertical Distribution of Invertebrate Taxa (by weight)

Taxon	*0-20 cm*	*20-40 cm*	*40-50 cm*	*50-60 cm*	*60-70 cm*	*70-80 cm*	*80-90 cm*	*90-100 cm*	*100-110 cm*	*110-120 cm*	*120-130 cm*	*130-140 cm*	*140-150 cm*
Gastropoda													
Gastropod, undif.	—	—	—	0.15	0.71	—	0.76	0.38	0.87	0.19	—	—	—
Crepidula spp.	—	—	—	—	—	0.17	0.08	—	—	—	—	—	—
Haliotis spp.	—	1.91	4.66	—	—	—	—	0.84	—	—	2.38	—	—
Olivella biplicata	—	—	—	0.21	—	—	—	—	—	—	—	—	—
Tegula spp.	—	—	—	—	—	—	0.71	2.82	0.37	—	—	—	—
Trivia spp.	—	—	—	—	—	—	—	0.16	—	—	—	—	—
Pelecypoda													
Pelecypod, undif.	—	—	—	—	—	—	—	—	—	—	—	—	—
Chione spp.	38.85	82.45	30.45	99.07	72.93	42.24	12.04	8.16	33.50	4.72	—	0.29	1.96
Donax gouldii	519.14	893.10	517.81	610.53	556.03	171.04	81.59	106.01	37.14	21.16	24.33	7.46	4.42
Mytilus spp.	2.90	2.87	0.33	0.28	1.00	5.78	0.14	7.98	6.15	1.45	1.52	—	0.26
Ostrea lurida	0.24	5.65	2.92	5.98	11.18	9.53	20.07	20.44	16.72	5.75	8.84	1.27	0.60
Pectinidae	11.17	18.47	21.83	45.41	51.11	60.33	82.23	64.90	105.29	28.07	16.13	0.88	6.42
Protothaca spp.	2.57	9.60	17.26	12.23	11.51	1.97	5.23	2.91	—	1.45	2.27	—	—
Septifer bifurcatus	—	—	—	—	—	—	—	1.20	—	—	—	—	—
Tagelus californianus	—	0.85	1.22	0.49	—	0.33	0.50	0.29	0.41	—	—	—	—
Tivela stultorum	18.77	37.51	72.91	49.30	70.77	17.25	14.43	11.75	3.46	—	—	—	—
cf. *Tresus nuttallii*	—	—	—	—	—	6.98	—	2.20	—	—	—	—	—
Veneridae	132.38	191.77	80.81	84.05	54.29	26.52	28.01	15.94	21.54	21.73	13.69	2.29	0.19
Other Invertebrates													
Chiton, undif.	—	—	—	—	—	0.67	—	1.87	1.01	—	0.98	—	—
Balanus spp.	—	—	—	—	—	—	—	0.30	1.37	—	0.16	—	—
Crab, undif.	—	—	0.13	—	—	0.31	0.19	0.99	1.49	0.21	—	—	—
Shell, undif.	2.24	1.89	2.48	1.89	1.62	2.76	0.60	1.52	5.76	1.90	2.10	0.17	—
Total	728.26	1,246.07	752.81	909.59	831.15	345.88	246.58	250.66	235.08	86.63	72.40	12.36	13.85

The five analytic units exhibit dramatic differences in the density of invertebrate remains (Table 8-4). AU 1 (Units 100 & 122, 0-70 cm), which dates to the Late Prehistoric or San Luis Rey period, has the highest density of shellfish remains for the entire site (see Table 5-2).

Table 8-4. Density of Invertebrate Remains Based on the Analytical Units from CA-SDI-811

AU	*Volume Excavated (m^3)*	*Weight (g)*	*Density (g/m^3)*	*Cultural Period*
AU 1	1.4	3,664.29	2,617.35	Late Prehistoric (LP)
AU 2	0.6	0.15	0.25	Late Prehistoric
AU 3	0.6	51.81	86.35	Transition between LP & Archaic
AU 4	1.2	4.81	4.01	Archaic
AU 5	0.6	76.48	127.47	Transition between LP & Archaic

Surprisingly, AU 2 (Unit 109, 0-60 cm) and AU 3 (Unit 109, 90-150 cm), which correlate with a separate midden area, have only minor to moderate densities of shellfish remains. AU 3 falls into the transition between the Archaic and Late Prehistoric Period, and AU 2 presumably dates to a later occupation (based on its vertical placement within the unit).

Another surprise was the difference between AU 4 (FAR I) and AU 5 (FAR II). These two AU's represent two distinct scatters of fire-affected rock. The rock clusters look very similar in composition and probably relate to hearth clean-outs. Despite their visual similarities, they are chronologically distinct. FAR I dates to the Archaic Period and FAR II falls into the transition between the Archaic and Late Prehistoric periods. Moreover, the amount of shellfish remains differs dramatically between the two scatters suggesting that the two hearth areas had been used for different purposes.

Besides differences in density calculations, the AU's differ in terms of diversity of shellfish remains. Table 8-5 provides a breakdown of the AU shellfish assemblages by taxonomic identification. AU 1 contains nine mutually exclusive categories of shellfish and is dominated by bean clams (*Donax gouldii*). In fact, approximately 72 percent (by weight) of all *Donax* remains from the entire site were recovered from AU 1. The various clam species in the Veneridae family (e.g., *Chione* spp., *Protothaca* spp., *Tivela stultorum*) make up the next largest component of AU 1, followed by the scallops (Pectinidae) and the oysters (*Ostrea lurida*). AU 1 contributed over 63 percent of all shellfish recovered from the site and dominates overall patterns of shellfish exploitation.

AU 2 has the smallest assemblage of shellfish remains of all of the AU's as well as the lowest diversity. The entire assemblage consists of 0.15 g of *Donax* recovered from the 0-20 cm level. The density and diversity of shellfish increases in the lower deposit of this unit (AU 3). AU 3 contains nine mutually exclusive categories of invertebrates, which is the same as AU 1. While *Donax* remains dominated AU 1, scallops (Pectinidae) dominated AU 3. The scallops were followed by the Veneridae clam family, bean clam, and then a wide variety of more rocky-shore inhabitants, such as mussels, chitons, barnacles, and various gastropods.

AU 4 (FAR I) and AU 5 (FAR II) also differ in terms of diversity and composition of assemblage. AU 4 contains only three mutually exclusive categories: *Donax gouldii*,

Table 8-5. Taxonomic Representation of Invertebrates Based on the Analytical Units of CA-SDI-811

	AU 1			AU 2			AU 3			AU 4			AU 5		
Taxon	*Weight (g)*	*Density (g/m³)*	*MNI (ct)*	*Weight (g)*	*Density (g/m³)*	*MNI (ct)*	*Weight (g)*	*Density (g/m³)*	*MNI (ct)*	*Weight (g)*	*Density (g/m³)*	*MNI (ct)*	*Weight (g)*	*Density (g/m³)*	*MNI (ct)*
Gastropoda															
Gastropod, undif.	0.86	0.61	–	–	–	–	0.04	0.07	–	–	–	–	–	–	–
Crepidula spp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Haliotis spp.	–	–	–	–	–	–	2.38	3.97	1	–	–	–	–	–	–
Olivella biplicata	0.21	0.14	1	–	–	–	–	–	–	–	–	–	–	–	–
Tegula spp.	–	–	–	–	–	–	0.82	1.37	1	–	–	–	–	–	–
Trivia spp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pelecypoda															
Pelecypod, undif.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chione spp.	267.70	191.21	22	–	–	–	–	–	–	–	–	–	43.31	72.18	3
Donax gouldii	2,554.66	1,824.76	3,520	0.15	0.25	1	2.83	4.72	8	3.36	2.80	6	0.91	1.52	1
Mytilus spp.	0.59	0.42	1	–	–	–	1.48	2.47	1	–	–	–	0.28	0.47	1
Ostrea lurida	17.09	12.21	12	–	–	–	1.39	2.32	1	–	–	–	4.59	7.65	2
Pectinidae	110.36	78.83	24	–	–	–	32.50	54.17	3	0.27	0.23	1	11.07	18.45	3
Protothaca spp.	49.18	35.13	7	–	–	–	–	–	–	–	–	–	–	–	–
Septifer bifurcatus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tagelus californianus	2.56	1.83	1	–	–	–	0.33	0.55	1	–	–	–	–	–	–
Tivela stultorum	235.99	168.56	16	–	–	–	–	–	–	–	–	–	–	–	–
cf. *Tresus nuttallii*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Veneridae	421.93	301.38	–	–	–	–	4.37	7.28	–	1.06	0.88	1	15.58	25.97	–
Other Invertebrates															
Chiton, undif.	–	–	–	–	–	–	1.67	2.78	1	–	–	–	–	–	–
Balanus spp.	–	–	–	–	–	–	1.21	2.02	–	–	–	–	–	–	–
Crab, undif.	–	–	–	–	–	–	–	–	–	–	–	–	0.13	0.22	–
Shell, undif.	3.16	2.26	–	–	–	–	2.79	4.65	–	0.12	0.10	–	0.61	1.02	–
Total	3,664.29	2,617.35	3,604	0.15	0.25	1	51.81	86.35	17	4.81	4.01	8	76.48	127.47	10

Veneridae, and Pectinidae (in that order of abundance). AU 5 contains six mutually exclusive categories of invertebrates: *Chione* spp., the rest of the Veneridae family, scallops, oysters, and bean clam, the latter of which composes only a small percentage (1.2 percent by weight) of AU 5's invertebrate assemblage.

Discussion

SDI-811 displays variations in the vertical, horizontal, and temporal distributions of shellfish remains. The deposits from the Archaic Period (AU 4 or FAR I) contained a low density of invertebrate remains with a fairly low degree of richness in species present. Density and diversity of species increased during the transition between the Archaic Period and the Late Prehistoric, the period that some associate with the influx of Yuman speaking or Shoshonean peoples. The Late Prehistoric deposit, represented by AU 1, exhibits the site's highest density and, along with AU 3, the site's highest diversity of invertebrate remains. This general trend toward higher density and diversity of invertebrate remains through time may represent a dietary shift toward an increased reliance on shellfish exploitation. Alternatively, the density and diversity of shellfish remains from the most recent deposits may correlate with either a longer duration of occupation during this period or the use of this zone as a specialized shellfish/*Donax* processing area. These alternatives will be explored in Chapter 11, when density and diversity information from all classes of data is evaluated.

The material from AU 2 does not fit into the above pattern. Based on stratigraphic position, this component likely dates to the Late Prehistoric, sometime between AU 3 and AU 1. It contained very little shellfish remains (0.15 g of *Donax*) and also exhibited low densities of artifacts and animal bone. It appears that use of this portion of the site during this time period was very ephemeral.

8.5 INTER-SITE ANALYSIS

The invertebrate remains from the Red Beach site were compared to the assemblages from other Camp Pendleton sites in order to identify changes in resource diversity and habitat exploitation over time. Nine sites, in addition to SDI-811, were chosen for this analysis, including three sites from the Las Flores Creek area (SDI-812/H, -10726 Locus A & B, -10728 Locus A & B) (see Figure 1-6), one from Horno Canyon (SDI-4538) (see Figure 1-7), four from San Onofre Creek area (SDI-1074, -4411, -12574, -13748) (see Figure 1-7), and one site from San Mateo Creek (SDI-13325) (see Figure 1-7).

Measuring the diversity of archaeological assemblages is a useful means of comparing different sites. Differences in the diversity of the material found at a site may relate to the duration of occupation, the resource zones exploited, site functions, and/or disposal patterns (Woodman et al. 1991). Diversity can also be affected by sample size differences, which is a potential problem with the shellfish assemblages from the various sites at Camp Pendleton. Larger collections often have more diverse assemblages than smaller collections simply because of the nature of sampling (Kintigh 1989). Diversity analysis can control for the effects of sample size, which is a major contributor to the problems involved with interpreting faunal assemblages (Grayson 1981).

The Shannon-Weaver information statistic is a widely used diversity measure. It is calculated as follows:

$$S_d = -\sum_j p_j \log p_j$$

where the proportion of each taxon, p_j, equals n_j/N. In this case, the value of n_j equals the weight (in grams) per taxon, and the value of N equals the total weight of the invertebrate assemblage for the site.

The Shannon-Weaver value is affected by the richness of the assemblage, or the number of taxa, and by the evenness of the assemblage, that is, the differences in the proportion each taxon contributes to the total assemblage. For example, in an assemblage with only three taxa, S_d can range from 0 to no higher than 0.477. In an assemblage with 11 taxa, S_d can range from 0 to as high as 1.300. This means that a diversity of 0.470 would be considered high for the former assemblage and moderate to low for the latter assemblage. The effect of the number of taxa can be taken into consideration by calculating evenness, a measure of the relationship between the distribution of individuals among taxa and the most even distribution of individuals attainable given the number of taxa represented. The formula for evenness is as follows:

$$E = S_d/S_{d(max)}$$

where S_d equals the Shannon-Weaver value and $S_{d(max)}$ is the highest value of S_d obtainable for a particular number of taxa. $S_{d(max)}$ equals log S, where S is the total number of taxa.

Table 8-6 provides the richness and evenness calculations from the 10 selected sites. These data and sample size values are illustrated in Figures 8-1 and 8-2. Note that diversity measures for SDI-811 largely reflect the Late Prehistoric midden represented by AU 1.

Richness values for the 12 sites ranged from 9 mutually exclusive taxa to as many as 41 (Table 8-6, Figure 8-1). SDI-13325, classified as a residential base camp (Byrd et al. 1995), had the highest degree of richness of the tested sites. The sites with the lowest richness values (SDI-13748, -12574, -10728 Locus B, -10726 Locus A) come from Las Flores Creek and San Onofre Creek. It is interesting to note that the low degrees of richness do not necessarily correlate with sample size. The two San Onofre sites actually have a rather high degree of richness for their small sample size while the Las Flores Creek sites have lower richness than would be expected for their sample size. For example, the assemblage from SDI-13748 contains 11 mutually exclusive invertebrate taxa although the entire assemblage only consists of 15 grams of shellfish. SDI-10728, Locus B, has the same richness value although the assemblage contains over 8,000 grams of shellfish.

The relatively wide range of invertebrate species represented at the two low density sites indicates that even fairly short-term occupations can involve the exploitation of a variety of resources and that occupations of higher density and presumably longer duration do not necessarily result in greater richness. Although occupations of varying length appear to be associated with a wide range of species, were any of these occupations correlated with the

Table 8-6. Invertebrate Diversity Analysis

Site	*Cultural Period*	*Total Weight (g)*[1]	*Richness*	*Evenness*
SDI-811[2]	Archaic/Late Prehistoric	5,032.47	18	0.374
SDI-812/H[3]	Late Prehistoric/Ethnohistoric	10,782.72	17	0.034
SDI-10726, Locus A[5]	Late Archaic/Late Prehistoric	6,499.5	9	0.023
SDI-10726, Locus B[5]	Early Archaic/Late Prehistoric	18,582	24	0.472
SDI-10728, Locus A[6]	Early Archaic/Late Prehistoric	40,992.9	28	0.299
SDI-10728, Locus B[6]	Late Prehistoric	8,493.7	11	0.014
SDI-4538[5]	Late Archaic/Late Prehistoric	23,025.5	14	0.010
SDI-1074[4]	Late Prehistoric	2,645.7	20	0.241
SDI-4411[4]	Late Prehistoric	11,257.3	33	0.357
SDI-12574[4]	Not Dated	31.5	9	0.355
SDI-13748[4]	Not Dated	15	11	0.706
SDI-13325[4]	Late Archaic/Late Prehistoric	26,519.7	41	0.367

[1] Total weight (in grams) calculated for only mutually exclusive invertebrate taxa.
[2] From current project only
[3] From Cagle et al. 1996b
[4] From Byrd et al. 1995
[5] From Byrd et al. 1996
[6] From Byrd et al. 1997

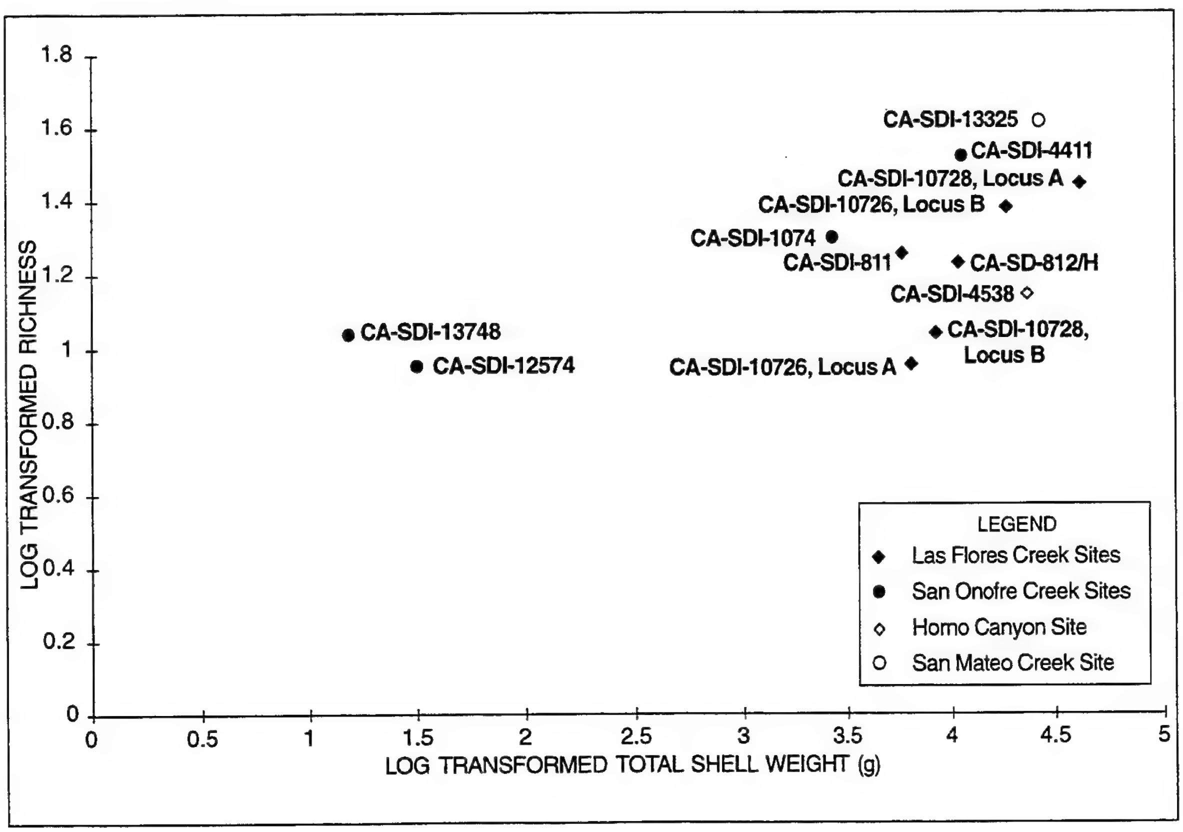


Figure 8-1. Richness of the Invertebrate Assemblages

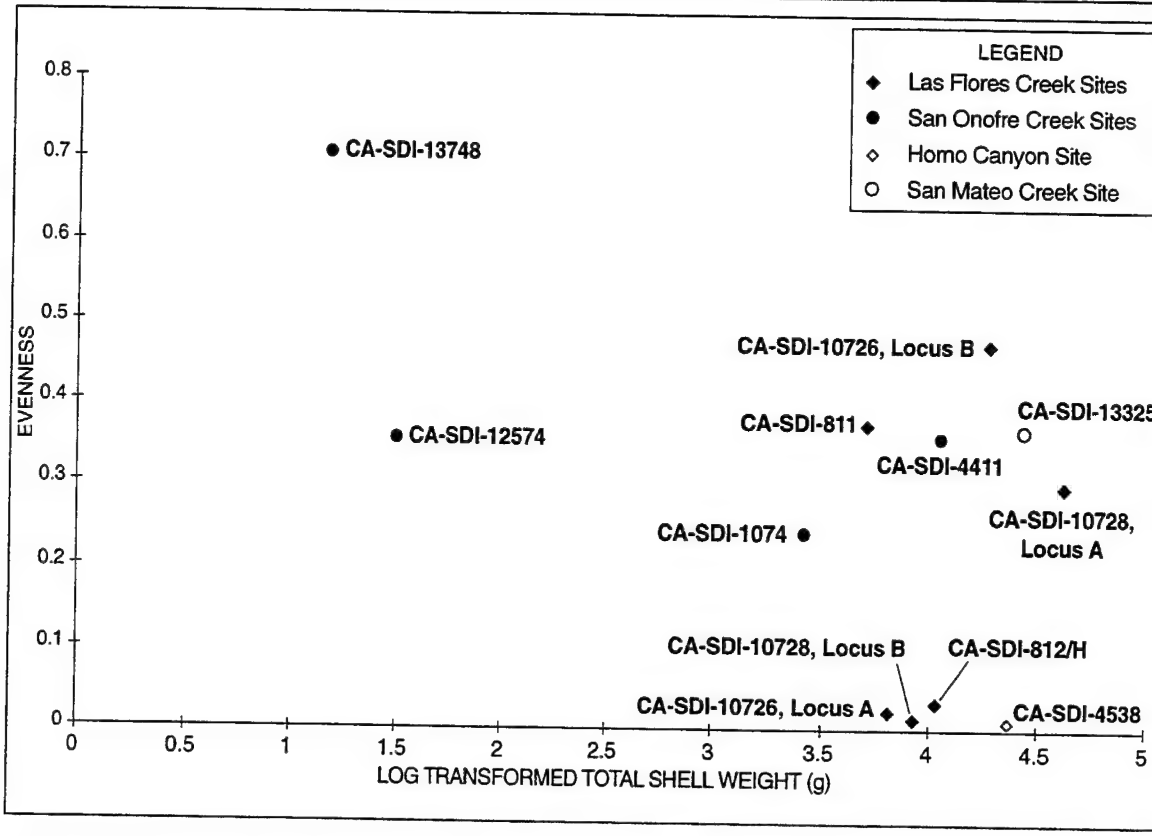


Figure 8-2. Evenness of the Invertebrate Assemblages

intensive exploitation of a single species? To address this question, we need to examine the relative importance of the various taxa, or evenness, within the assemblages.

The evenness in the distribution of invertebrate taxa among the various sites is displayed in Figure 8-2. A low evenness score suggests that one or a few taxa dominate the assemblage and that the inhabitants specialized in the exploitation of specific species of shellfish. A high evenness score, on the other hand, suggests that the various taxa were recovered in about equal abundance and that the inhabitants utilized a more generalized collection strategy.

Four sites (SDI 812/H, -4538, -10726 Locus A, -10728 Locus B) had a low degree of evenness for their sample size (Figure 8-2), implying some degree of specialization in one or a few species. In all four cases, *Donax* clearly dominated the assemblages. In order to compare the importance of *Donax* at the ten sites, the percentage of *Donax* remains from each was calculated (Table 8-7). This percentage is based on the weight of *Donax* remains from a site divided by the total weight for all mutually exclusive taxonomic designations only.

In the four cases mentioned above, *Donax* remains composed over 98 percent of the respective collections. In fact, all of the sites or site loci with a high percentage (over 50 percent) of *Donax* remains were located in either Las Flores Creek or Horno Canyon. *Donax* was recovered from sites farther north in San Onofre and San Mateo Canyons, but the bean

Table 8-7. Percentage of *Donax* Recovered from Various Camp Pendleton Sites

Site	*Cultural Period*	*Total Shell Weight[1] (g)*	*Donax Weight (g)*	*% of Donax*
SDI-4538	Late Archaic/Late Prehistoric	23,025.5	22,958.0	99.71
SDI-10728, Locus B	Late Prehistoric	8,493.7	8,457.7	99.58
SDI-10726, Locus A	Late Archaic/Late Prehistoric	6,499.5	6,454.0	99.30
SDI-812/H	Late Prehistoric/Ethnohistoric	10,782.72.0	10,619.6	98.49
SDI-811	Archaic/Late Prehistoric	5,032.5	3,549.8	70.54
SDI-10726, Locus B	Early Archaic/Late Prehistoric	18,582.0	3,571.0	19.22
SDI-13748	Not Dated	15.0	1.7	11.33
SDI-4411	Late Prehistoric	11,257.3	873.4	7.76
SDI-10728, Locus A	Early Archaic/Late Prehistoric	40,992.9	2,315.0	5.65
SDI-1074	Late Prehistoric	2,645.7	87.5	3.31
SDI-13325	Late Archaic/Late Prehistoric	26,519.7	0.3	0.01
SDI-12574	Not Dated	31.5	0.0	0.00

[1] Total weight calculated for only mutually exclusive invertebrate taxa.

clam never seemed to generate the same level of importance. The Late Archaic/Late Prehistoric assemblages in the more northern areas are dominated by *Protothaca* and *Tegula* instead of sandy-shore *Donax*. Similar trends were noted by Byrd et al. (1997), and they suggest that during the Late Archaic/Late Prehistoric periods, the large-sized drainages to the north – San Onofre and San Mateo – still contained viable bay and rocky area habitats while the smaller drainages to the south--Las Flores Creek and Horno Canyon--had developed sandy-shore habitats by this time.

In addition to geographical factors, *Donax* remains appear to be concentrated primarily in Late Archaic/Late Prehistoric deposits. The invertebrate remains from two Early Archaic deposits within the Las Flores Creek (SDI-10726 Locus B and -10728 Locus A) were notable because they were dominated by shellfish from bay, estuary, and rocky-shore settings, not sandy habitats (Byrd et al. 1996, 1997). It appears that mass harvesting of *Donax* did not become a major economic activity until the Late Holocene (Byrd et al. 1997:140). In fact, the bean clam could not have existed along these shorelines until after 4,000 years ago because of changes in the local paleoecological setting (Byrd et al. 1996:70) so it is not surprising that *Donax* exploitation was a relatively late phenomenon.

Although the variations in shellfish exploitation strategies between the Camp Pendleton sites may be related to temporal, logistical, or seasonal factors, it is interesting to note that geographic location also appears to be a factor. The ecological setting along Las Flores Creek and Horno Canyon probably offered better habitats for the sand-loving bean clam than the drainages further north, at least during the last two thousand years. Despite the intensity of *Donax* exploitation at the four sites mentioned above, none of the occupations appear to be specialized shellfish processing or consumption sites (Byrd et al. 1996, 1997; Cagle et al. 1996b).

8.6 SHELL ARTIFACTS

Three shell artifacts were recovered from the 1997 excavations at SDI-811. Two of the artifacts were abalone pendants, one of which was perforated (Catalog # 699), and the other was an unfinished blank (Catalog # 1461). The perforated pendant (Figure 8-3) is roughly circular around 75 percent of the artifact. It actually looks roughly shield-like in shape. It ranges from 19.8 mm to 23.5 mm in diameter, and the perforation is 4.9 mm in diameter. The pendant blank is roughly rectangular in shape (29.6 x 18.0 mm).

The final shell artifact was a spire-lopped *Olivella* bead (Catalog # 1584; Figure 8-3). The *Olivella* bead is composed of a whole, small *Olivella biplicata* shell with the spire removed in a perpendicular fashion (Gibson 1992). It is approximately 5.4 mm in diameter, 7.3 mm in length and has a 3.1 mm hole diameter. The bead also displays signs of weathering. This type of bead is fairly common throughout the California cultural sequence (Gibson 1992; King 1990) and is not a very useful temporal marker.

The two pendants were recovered from the excavations and column sample of Unit 109. The perforated pendant was found at a depth of 120-130 cm (within AU 3, an Archaic/Late Prehistoric transitional period), and the blank at 70-80 cm in depth. The *Olivella* bead was recovered in Unit 121, which lies in between the two fire-affected rock areas. The sample size of shell artifacts is rather small, and does not reveal any spatial or temporal trends within the Red Beach archaeological assemblage.

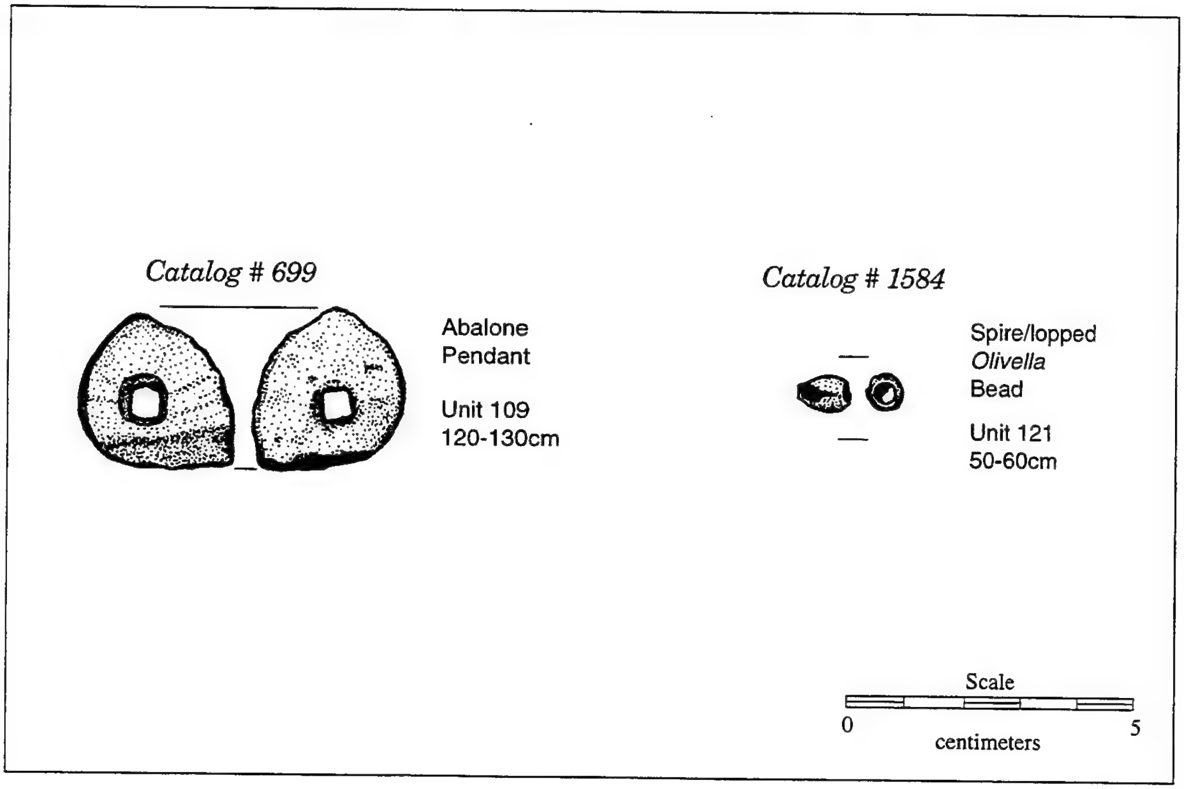


Figure 8-3. Shell Artifacts from SDI-811

8.7 SUMMARY

The invertebrate assemblage from the Red Beach site contains 5,733.36 grams of shellfish from 18 mutually exclusive taxonomic species. Despite the high diversity of invertebrates, only a few species dominate the assemblage. These include *Donax*, the Veneridae clams, and scallops. The rest of the species play only a minor role in the overall assemblage, ranging from 1.904 percent to as low as 0.003 percent of the entire collection (based on weight). Although the shellfish originate from a variety of habitats, the overall assemblage indicates a pronounced emphasis on the exploitation of sandy shores with a moderate exploitation of bays and/or marine estuaries. Rocky shore species are present, but in low numbers. The emphasis on sandy-shore inhabitants is not surprising given the beachside location of the site.

The site displays variations in the horizontal, vertical, and temporal distribution of invertebrate remains. Based on the density and diversity of species within the five analytical units derived for the site, it appears that there is a general pattern toward higher density and diversity of species over time. This may correlate with a dietary shift toward an increased reliance on shellfish exploitation; however, this pattern can also be explained as a consequence of either increased duration of occupation over time or a change toward using the site as a specialized shellfish processing area. These issues are addressed further in Chapter 11.

Finally, the assemblage from the Red Beach site was compared to the assemblages from nine additional sites within the Camp Pendleton region. All of the assemblages had relatively high degrees of richness, despite wide variations in sample size. This implies that even fairly short-term occupations can involve the exploitation of numerous invertebrate species from various habitats and that occupations of higher density and presumably longer duration do not necessarily result in a greater degree of richness. In addition, sites within Las Flores Creek and Horno Canyon have much higher percentages of *Donax* remains in their assemblages than sites based in San Onofre or San Mateo Creek. The large-size drainages of San Onofre and San Mateo Creek developed different ecological habitats for shellfish than the smaller Las Flores Creek and Horno Canyon drainage systems. It appears that the latter two developed the types of sandy shore expanses preferred by bean clams.

9 ISOTOPIC ANALYSES OF *Donax gouldii*

Douglas J. Kennett

9.1 INTRODUCTION

The oxygen and carbon isotopic composition of *Donax gouldii* (bean clams) shells from SDI-811 were measured to determine patterns of prehistoric mollusc harvesting. To provide a comparative database, similar information was collected from a well-dated Late Prehistoric component within a nearby site, SDI-812/H (see Figure 1-6). Studies of modern marine molluscs from known environments indicate that oxygen isotopic analysis is an effective method for reconstructing sea-surface temperature (Epstein et al. 1951, 1953; Glassow et al. 1994; Kennett 1996; Kennett and Voorhies 1995; Killingley 1981; Killingley and Berger 1979; Shackleton 1969, 1973). The ratio of ^{18}O to ^{16}O in seawater is temperature dependent and preserves in calcareous fossils, such as molluscs (Epstein et al. 1951, 1953; Wefer and Berger 1991). Incremental samples taken along the shell's growth axis enables reconstruction of oxygen isotopic ratios, and hence, seasonal temperature change through the life of a mollusc. Readings from the terminal growth margin of a shell indicates the sea temperature at the time the mollusc was collected.

9.2 *Donax gouldii*

Donax gouldii is a small marine bivalve found along sandy beaches from Acapulco, Mexico to Santa Barbara, California (Reddy 1996a). The northern extent of the species is debated, but the species is rarely seen north of Point Conception, California. The clams are found buried 4-5 cm deep in sand along a relatively narrow band in the intertidal zone, exposed at low tide and submerged at high tide (Reddy 1996a).

The average lifespan of *D. gouldii* is approximately 2 years. Some individuals will die during their first year of life, but most individuals die after spawning in their second year (Reddy 1996a). Few individuals survive long enough to spawn for a third time. Bean clams have a steady growth rate, reaching approximately 12mm in length during the first year and 18 mm in length by the end of the second (Reddy 1996a).

The growth margin of the shell is serrated or crenulated forming a set of interlocking teeth (Reddy 1996a). Concentric growth bands form on the surface of the bean clams shell during their lives and are most pronounced and widely spaced in older individuals. X-ray

diffraction indicates that the bean clam shell is composed primarily of aragonite. Relative to other molluscan species (i.e., *Mytilus californianus*), the crystalline structure *D. gouldii* is relatively simple (see Glassow et al. 1994).

9.3 OXYGEN ISOTOPIC ANALYSIS

Oxygen isotopic analysis of molluscan shell carbonate is a well established technique for determining sea-surface temperature and the season of prehistoric shellfish harvesting. The method was initially recognized as a powerful tool for paleoenvironmental reconstruction because oxygen isotopic ratios in calcareous fossils contain information about the physical and chemical environment of their growth (Wefer and Berger 1991). Two environmental factors contribute to the oxygen isotopic composition of shell carbonate: the isotopic composition of seawater and water temperature. Urey (1947) showed that the stable oxygen isotopic composition of calcium carbonate deposited by marine molluscs was temperature dependent and thus of great value as a paleothermometer. The oxygen isotopic composition of calcium carbonate differs from the water that it precipitates in when under equilibrium conditions. The isotopic exchange during precipitation of calcium carbonate from water can be expressed as:

$$\frac{1}{3}\mathrm{CaCO}_3^{16} + \mathrm{H}_2\mathrm{O}^{18} \Leftrightarrow \frac{1}{3}\mathrm{CaCO}_3^{18} + \mathrm{H}_2\mathrm{O}^{16}$$

Isotopic fractionation between carbonate and water during precipitation has a value of 1.0286‰ at 25°C (O'Neil et al. 1975). Because this fractionation factor is temperature dependent the $\delta^{18}O$ of carbonate is a function of temperature.

Epstein et al. (1951, 1953) developed a paleotemperature equation based on oxygen isotopic measurements of mollusc shell carbonate precipitated at known water temperatures. In the equation:

$$T=A - B(\delta c-\delta w) + C(\delta c-\delta w)^2$$

T is equal to temperature in °Celsius and A, B, and C are constants respectively equaling 16.4, 4.2, and 0.13. The symbol dc is the oxygen isotopic ratio of the carbonate, expressed as a deviation in ‰ (parts per mil) from a standard carbonate.

$$\delta c = \left(\frac{\delta^{18}\mathrm{O\ sample}}{\delta^{18}\mathrm{O\ standard}} - 1\right) \times 1000$$

δw represents the oxygen isotopic composition of the water expressed in a similar fashion, as a deviation from standard mean ocean water (smow). In order to solve the equation for temperature (T), the delta value of the water must be known. When the delta value for the water (δw) is constant, the oxygen isotopic ratio increases by approximately 0.2‰ for every 1°C increase in water temperature.

Thus, in the open ocean where the composition of sea-water has been relatively stable since the middle Holocene (~6000 years to present day; Fairbanks 1989), oxygen isotopic measurements of calcium carbonate extracted from the sequential growth increments of molluscs reflect seasonal fluctuations in water temperature and the season of molluscan death can be estimated. Shackleton (1969) was the first to point out the applicability of this technique for archaeologists interested in determining the season of mollusc collection from shells in archaeological deposits.

Paleotemperature equations for inferring sea-surface temperature have been refined for calcite and aragonite, two different mineral phases of calcium carbonate (Horibe and Oba 1972). Epstein et al. (1953) based their equation on organically precipitated calcium carbonate in the molluscs of the genus *Haliotis*, a large gastropod with a complex mineral structure consisting of both aragonite and calcite. Horibe and Oba (1972) determined that the relationship between sea-surface temperature and $\delta^{18}O$ is different for aragonite and calcite, based on two pelecypods from Mutsu Bay, Japan. Based on experiments with *Anadara broughtoni*, the temperature dependence of $\delta^{18}O$ in aragonite is expressed as:

$$t°C=13.85 - 4.54(\delta c\text{-}\delta w) + 0.04(\delta c\text{-}\delta w)^2$$

Based on experiments with *Patinopecten yessoensis*, the equation for calcite is:

$$t°C=17.04 - 4.34(\delta c\text{-}\delta w) + 0.16(\delta c\text{-}\delta w)^2$$

The methods for extracting seasonal information from mollusc shells were initially worked out by Shackleton (1973) and have changed little since. Calcium carbonate samples are extracted along a shell's growth axis from the growth margin towards the hinge. Using specimens of *Patella tabularis* collected alive from Nelsons Bay Cove, South Africa, Shackleton determined that oxygen isotopic changes through the growth of mollusc shells paralleled seasonal fluctuations in temperature and that the shell margin samples accurately reflected the season of molluscan death. Shells from prehistoric midden deposits in the region, dating between 9000 and 5000 years ago, indicated that molluscs were harvested primarily during winter (cold water) months.

Based on this study, Shackleton (1973) outlined a number of criteria that should be met to make seasonal temperature determinations using oxygen isotopic analysis. First, shell growth must take place under conditions of isotopic equilibrium with the surrounding water. Second, the isotopic composition of the water in which the shellfish lives must remain constant throughout the year. Third, the shell must precipitate carbonate throughout the year at a relatively fast rate. Finally, the seasonal temperature range must be greater than the week-to-week variations in temperature.

More recent literature has focused on establishing the precision of the oxygen isotopic method for determining seasonality. Based on a study of modern and archaeological *Mytilus californianus* specimens from the California coast, Killingley (1980, 1981; also see Glassow et al. 1994 and Killingley and Berger 1979) proposed that the month of prehistoric shellfish collection could be determined by statistical treatment of oxygen isotopic data. Bailey et al. (1983; also see Deith 1985) argued, in contrast, that determining the season of molluscan death to the month was unrealistic because of known oxygen isotopic differences between species and regional climatic variation through time.

9.4 CARBON ISOTOPIC ANALYSIS

Carbon isotopic changes ($\delta^{13}C$) in molluscs are more difficult to interpret and for this reason have received less study than oxygen isotopes (Wefer and Killingley 1980). Unlike oxygen isotopes, carbon isotopic variations are not temperature dependent. Carbon isotopic ($\delta^{13}C$) changes in the shells of marine molluscs have been found to reflect a combination of two primary factors: 1) the carbon isotopic composition of the water, and 2) the metabolic activity of the mollusc. Killingley and Berger (1979) recognized that carbon isotopic concentrations in California mussel shells generally correlate with changes in the marine carbon reservoir caused by coastal upwelling. Although these carbon isotopic fluctuations were associated with seasonal changes in the isotopic composition of the water through changes in upwelling, the signal in the shell was slightly out of phase. This difference was explained as a metabolic effect.

9.5 MODERN STUDY

A pilot study with modern *Donax gouldii* shells was conducted to assess the feasibility of using oxygen and carbon isotopic analyses to (1) reconstruct average and seasonal fluctuations in sea-surface temperature ($\delta^{18}C$); (2) reconstruct seasonal fluctuations in upwelling ($\delta^{13}C$); and (3) determine the season of prehistoric shellfish harvesting using shells from archaeological contexts (Kennett 1996). This pilot study indicates that oxygen isotopic ratios in their shells faithfully record seasonal fluctuations in water temperature (Kennett 1996). In contrast, carbon isotopic measurements appeared to be random with respect to changes in oxygen isotopic composition and less useful for reconstructing palaeoenvironmental change or season of molluscan harvesting.

Living *D. gouldii* specimens were collected in early April 1996, approximately 500 meters north of Scripps Pier, La Jolla, California. Incremental samples were extracted from two modern shells and the oxygen and carbon isotopic composition of the samples was measured using mass spectrometry.

The oxygen and carbon isotopic data for the two modern specimens from Scripps Pier are presented in Table 9-1 and Figure 9-1. Sample SAIC1 ranged 0.978‰ (parts per mil), between -0.381‰ and 0.917‰. Oxygen isotopic values in sample SAIC2 fluctuate 1.358‰ from -0.381‰ to 0.977‰. Oxygen isotopic values were compared to sea-temperatures measured at Scripps Pier between January 1995 and April 1996. Isotopic values tracked changes in sea-surface temperature during the life of the clam (Figure 9-2).

At the time of the modern study the type of carbonate in *Donax* was unclear. Horibe and Oba's (1972) calcite equation performed better than the aragonite equation when compared to actual water temperature measured at Scripps Pier, however both did equally well predicting the range of temperature change. X-ray diffraction has now been done on two specimens from the Rincon Point area, Santa Barbara county. *Donax* shells are comprised of aragonite not calcite. The temperature difference between the calcite and aragonite equation for the modern specimens is shown in Table 9-1. Again, the calcite equation performs better than the aragonitic equation which estimates water temperatures 2°C lower than measured water temperature at Scripps Pier. Clearly, controlled experiments with *Donax* are needed to calibrate oxygen isotopic values directly with water temperature. In the meantime, both values will be presented, but the calcite numbers will be used because they appear to reflect actual water temperature more accurately in the modern specimens.

9.6 METHODS-ARCHAEOLOGICAL STUDY

The present study focused on oxygen and carbon isotopic analyses of archaeological specimens of *Donax gouldii* from SDI-811 and SDI-812/H, two archaeological sites located on Camp Pendleton adjacent to Las Flores Creek. Oxygen and carbon isotopic measurements were done on *Donax* shells from one stratigraphic unit at SDI-812/H (A: Unit 19, 140-150cm) and two at SDI-811 (B: Unit 122, 50-60 cm and C: Unit 122, 80-90 cm). Seasonality determinations were made on eighteen shells from each stratigraphic unit (final growth increments). One full isotopic profile was also done for each stratigraphic unit (8 samples each).

All analyzed shells were from well-dated archaeological contexts. *Donax* shells from the SDI-812/H sample yielded a calibrated radiocarbon date of A.D. 1655-1800 (1-sigma range). This sample was taken from a deeply buried, well-preserved midden deposit. No artifactual evidence of historic contact was found and the deposit is interpreted as a Luiseño campsite. The shells from SDI-811 were selected from the high density shell midden (Unit 122). *Donax* from the upper sample (50-60 cm) yielded a 1-sigma calibrated date of A.D. 720-885, while *Donax* from the lower sample (80-90 cm) yielded a comparable date of A.D. 280-495.

In preparation for sampling, each archaeological shell was thoroughly cleaned with deionized water and baked in a conventional oven at 85°C until dry (Killingley and Berger 1979). The margin or lip of each archaeological specimen, representing the final stages of growth prior to harvesting, was removed with a dental drill. One *Donax* specimen per stratigraphic level was analyzed in greater detail to reconstruct sea-surface temperature throughout the life of the individual. Additional samples were extracted in 1mm increments along the growth axis of the shell. These samples were removed using a 0.5mm dental drill. This provides a context to interpret the final growth increment samples from each level.

Table 9-1. Oxygen and Carbon Isotopic Values for 2 *Donax* Shells Collected Near Scripps Pier, California in April of 1996

Sample #	*Dist (mm)*	*Oxygen*	*S.D.*	*Carbon*	*S.D.*	*Volts*	*Calcite (°C)*	*Aragonite (°C)*
SAIC1a	0	-0.015	0.018	1.325	0.014	0.185	17.89	14.74
SAIC1b	1	0.917	0.03	1.469	0.022	0.085	13.93	10.53
SAIC1c	2	0.896	0.007	1.328	0.011	0.072	14.01	10.62
SAIC1d	3	0.793	0.021	1.499	0.029	0.026	14.44	11.08
SAIC1e	4	0.382	0.057	1.688	0.016	0.027	16.17	12.93
SAIC1f	5	0.32	0.028	1.251	0.013	0.04	16.44	13.22
SAIC1g	6	0.35	0.044	1.682	0.02	0.052	16.31	13.08
SAIC1h	7	0.214	0.015	1.653	0.018	0.105	16.89	13.70
SAIC1i	8	-0.003	0.02	1.647	0.015	0.06	17.84	14.68
SAIC1j	9	0.073	0.016	1.234	0.019	0.05	17.51	14.34
SAIC1k	10	-0.061	0.019	1.337	0.02	0.064	18.10	14.95
SAIC2a	0	0.026	0.025	1.117	0.017	0.151	17.71	14.55
SAIC2b	1	0.796	0.043	1.327	0.023	0.048	14.43	11.07
SAIC2c	2	0.977	0.021	1.26	0.019	0.04	13.68	10.26
SAIC2d	3	0.964	0.019	1.279	0.014	0.065	13.74	10.32
SAIC2e	4	0.721	0.026	1.243	0.025	0.076	14.74	11.41
SAIC2f	5	0.358	0.018	0.528	0.011	0.075	16.27	13.04
SAIC2g	6	0.07	0.028	0.536	0.009	0.073	17.52	14.35
SAIC2h	7	-0.19	0.033	0.557	0.015	0.066	18.67	15.54
SAIC2i	8	-0.236	0.033	0.265	0.01	0.069	18.87	15.75
SAIC2j	9	-0.381	0.032	1.011	0.017	0.068	19.53	16.41
SAIC2k	10	-0.358	0.037	0.941	0.014	0.104	19.42	16.30

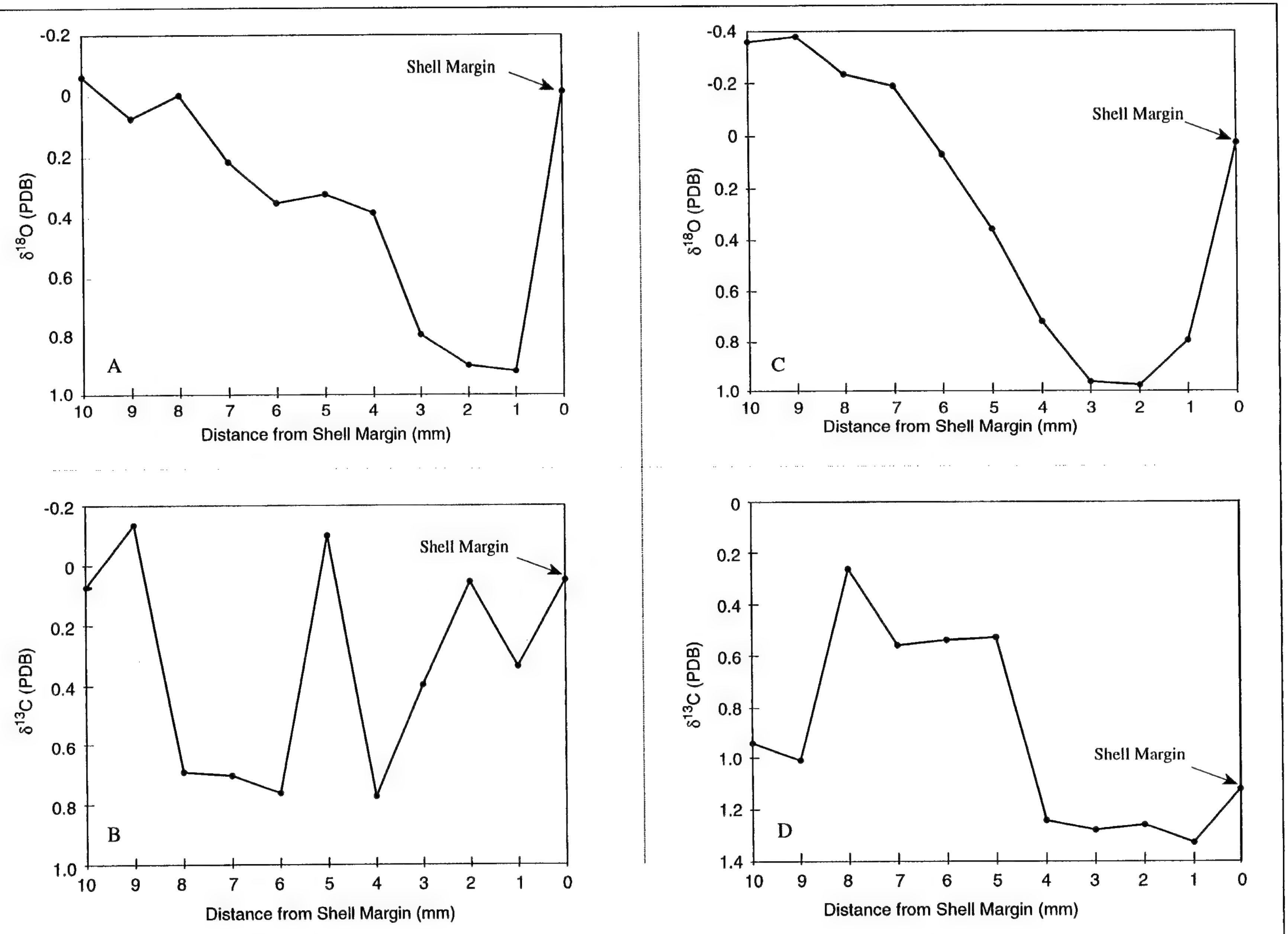
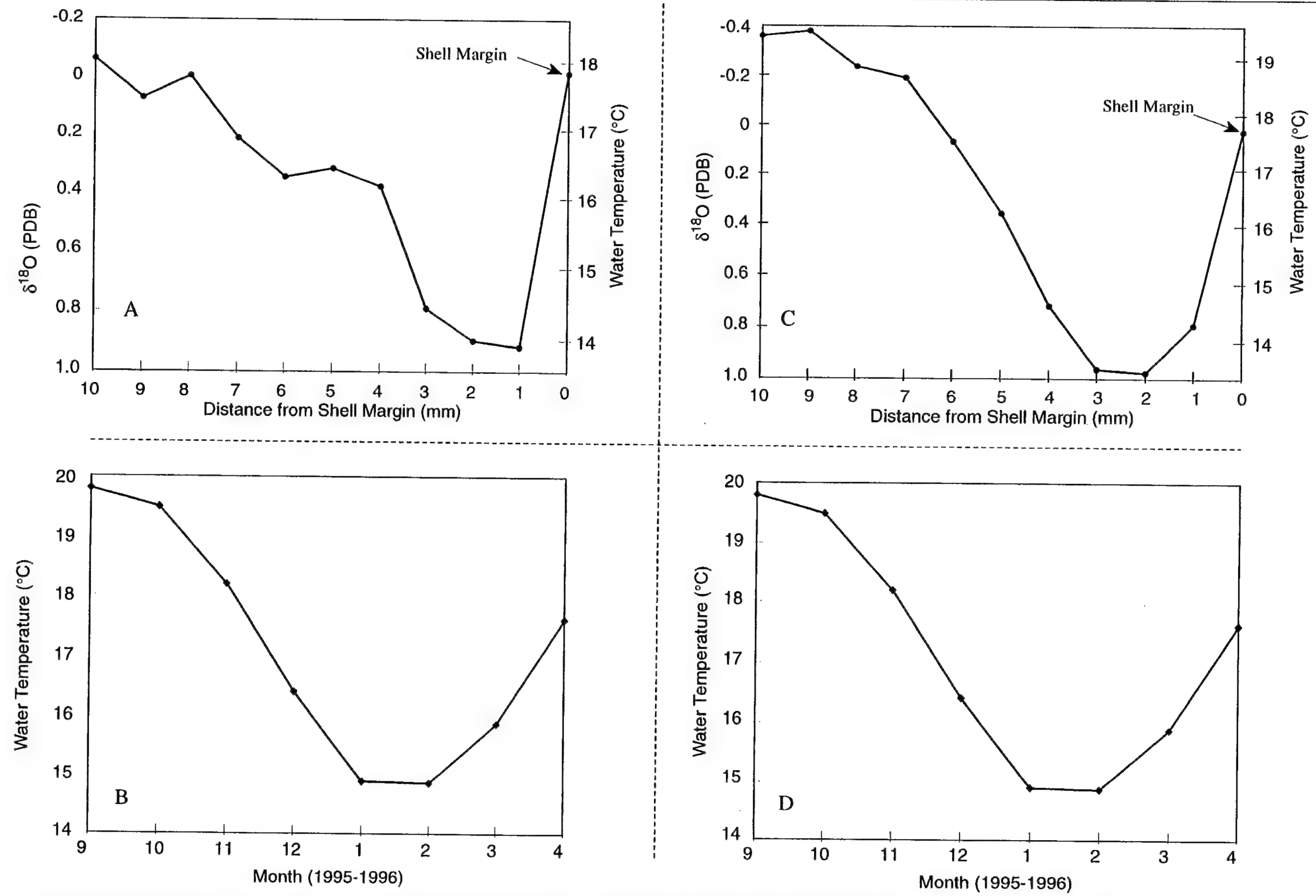


Figure 9-1. Oxygen and Carbon Isotopic Profiles for *Donax gouldii* Specimens SAIC1 (A & B) and SAIC2 (C & D)



Note: Temperature estimates in the upper profile are based on the calcite equation developed by Horibe and Oba (1972). Water temperatures in the lower profiles (B & D) were measured at Scripps Pier between September, 1995 and April, 1996.

Figure 9-2. Oxygen Isotopic Profiles for *Donax gouldii* Specimens SAIC1 (A) and SAIC2 (C)

Carbonate samples were loaded into small copper vessels and roasted, under vacuum, at 200°C for one hour. The roasting process oxidizes any remaining organic material that was not removed manually. After roasting, each pure calcium carbonate sample was reacted in orthophosphoric acid at 90°C. The oxygen and carbon isotopic ratios of the resulting CO_2 were determined by mass spectrometry (Finnegan MAT-251, Mass Spectrometer). All measurements are expressed as a deviation from an internationally accepted standard, PeeDee belemnite, a carbonate fossil from South Carolina (Herz 1990). The precision of the oxygen and carbon isotopic ratios is 0.1‰. More negative δ values indicate higher proportions of the lighter ^{16}O isotope relative to the heavier, and more common, ^{18}O isotope.

9.7 RESULTS

A total of 75 oxygen and carbon isotopic analyses were completed on 54 *Donax gouldii* shells from SDI-811 and SDI-812/H (Table 9-2). Full isotopic profiles were done on three *Donax* shells (8 measurements each), one from each stratigraphic level of interest. These oxygen and carbon isotopic values are presented in Table 9-3. Oxygen isotopic values along with water temperature estimates for calcite and aragonite are shown in Table 9-4.

The oxygen isotopic values for CA-SDI-812/H-A range from 0.211‰ (16.91°C) to -1.141‰ (23.05°C), an average of -0.365‰ (19.49°C) and a seasonal shift of 1.352‰ (Figure 9-3). Oxygen isotopic change is slightly less in sample CA-SDI-811-B (Figure 9-4), fluctuating 1.319‰ from -1.022‰ (22.49°C) to 0.297‰ (16.54°C), an average of -0.283‰ (19.11°C). Oxygen isotopic values for sample CA-SDI-811-C range from -0.576‰ (20.41°C) to 0.009‰ (17.79°C) an average of -0.333‰ (19.79°C) (Figure 9-5). The overall range of CA-SDI-811-C is significantly smaller (0.585‰) than samples CA-SDI-812/H-A and CA-SDI-811-B.

Carbon isotopic values also fluctuate within each of the three *Donax* specimens analyzed. The largest carbon isotopic shifts occur in sample CA-SDI-812/H-A (Figure 9-3). In this shell, carbon isotopic ratios ranged from 1.352‰ to 2.371‰ (total range of 1.019‰). This parallels large shifts evident in oxygen isotopic ratios in the same shell. Carbon isotopic ratios are less pronounced in sample CA-SDI-811-B (Figure 9-4), shifting 0.768‰, from 1.497‰ to 2.265‰. The smallest carbon isotopic range occurs in CA-SDI-811-C (Figure 9-5).

The oxygen isotopic composition of all final growth increment samples for each stratigraphic unit are presented in Table 9-5, along with temperature estimates for calcite and aragonite. Final growth increment samples are plotted against the full oxygen isotopic range exhibited in the profiles from each level (Figure 9-6). The oxygen isotopic measurements at CA-SDI-812/H-A range from 0.086‰ (17.45°C) to -0.797‰ (21.43°C), but most values are concentrated between -0.273‰ (19.04°C) and -0.797‰ (21.43°C). Growth increment samples at CA-SDI-811-B range from 0.341‰ and -0.563‰ and occur fairly evenly across this range. A similar pattern occurs in CA-SDI-811-B, but a substantial gap occurs between -0.5‰ and -0.75‰.

Table 9-2. Results of Oxygen and Carbon Isotopic Analyses on 54 *Donax gouldii* Shells from CA-SDI-811 and CA-SDI-812/H

(page 1 of 2)

Site	*Sample*	*Species*	*Dist (mm)*	*Oxygen*	*S.D.*	*Carbon*	*S.D.*	*Volts*
SDI-812/H	A1a	*Donax gouldii*	0	0.024	0.016	1.953	0.019	0.034
SDI-812/H	A1b	*Donax gouldii*	1	-1.141	0.037	2.371	0.015	0.050
SDI-812/H	A1c	*Donax gouldii*	2	-0.704	0.017	1.352	0.018	0.052
SDI-812/H	A1d	*Donax gouldii*	3	-0.066	0.026	1.592	0.012	0.056
SDI-812/H	A1e	*Donax gouldii*	4	0.211	0.034	1.743	0.016	0.032
SDI-812/H	A1f	*Donax gouldii*	5	-0.363	0.026	1.736	0.005	0.061
SDI-812/H	A1g	*Donax gouldii*	6	-0.859	0.015	1.709	0.047	0.047
SDI-812/H	A1h	*Donax gouldii*	7	-0.023	0.030	1.865	0.016	0.070
SDI-812/H	A2a	*Donax gouldii*	0	-0.360	0.017	2.135	0.010	0.066
SDI-812/H	A3a	*Donax gouldii*	0	-0.784	0.015	2.048	0.020	0.068
SDI-812/H	A4a	*Donax gouldii*	0	-0.411	0.015	1.847	0.013	0.044
SDI-812/H	A5a	*Donax gouldii*	0	-0.519	0.022	1.952	0.018	0.037
SDI-812/H	A6a	*Donax gouldii*	0	-0.716	0.024	1.944	0.016	0.079
SDI-812/H	A7a	*Donax gouldii*	0	-0.390	0.020	1.954	0.011	0.106
SDI-812/H	A8a	*Donax gouldii*	0	-0.533	0.030	2.392	0.013	0.093
SDI-812/H	A9a	*Donax gouldii*	0	0.086	0.031	2.128	0.015	0.083
SDI-812/H	A10a	*Donax gouldii*	0	-0.291	0.022	1.977	0.018	0.100
SDI-812/H	A11a	*Donax gouldii*	0	-0.535	0.024	2.025	0.009	0.070
SDI-812/H	A14a	*Donax gouldii*	0	-0.791	0.047	2.495	0.015	0.059
SDI-812/H	A15a	*Donax gouldii*	0	-0.273	0.021	1.553	0.012	0.042
SDI-812/H	A16a	*Donax gouldii*	0	-0.463	0.027	1.730	0.008	0.040
SDI-812/H	A17a	*Donax gouldii*	0	-0.534	0.020	1.869	0.020	0.031
SDI-812/H	A18a	*Donax gouldii*	0	-0.797	0.034	2.245	0.016	0.078
SDI-812/H	A19a	*Donax gouldii*	0	-0.754	0.030	2.496	0.019	0.036
SDI-812/H	A20a	*Donax gouldii*	0	-0.411	0.026	1.545	0.009	0.032
SDI-811	B1a	*Donax gouldii*	0	-0.563	0.031	1.908	0.025	0.045
SDI-811	B1b	*Donax gouldii*	1	0.057	0.033	1.940	0.006	0.047
SDI-811	B1c	*Donax gouldii*	2	-0.469	0.036	2.066	0.014	0.064
SDI-811	B1d	*Donax gouldii*	3	0.297	0.033	2.265	0.013	0.036
SDI-811	B1e	*Donax gouldii*	4	-1.022	0.024	1.770	0.011	0.068
SDI-811	B1f	*Donax gouldii*	5	-0.443	0.030	1.817	0.022	0.124
SDI-811	B1g	*Donax gouldii*	6	-0.071	0.035	1.497	0.017	0.038
SDI-811	B1h	*Donax gouldii*	7	-0.051	0.023	1.884	0.022	0.058
SDI-811	B2a	*Donax gouldii*	0	-0.175	0.030	1.584	0.011	0.052
SDI-811	B4a	*Donax gouldii*	0	0.156	0.029	1.782	0.018	0.076
SDI-811	B5a	*Donax gouldii*	0	0.120	0.012	2.104	0.022	0.076
SDI-811	B6a	*Donax gouldii*	0	-0.260	0.037	2.108	0.019	0.056
SDI-811	B7a	*Donax gouldii*	0	-0.237	0.024	2.018	0.021	0.137
SDI-811	B8a	*Donax gouldii*	0	0.260	0.033	2.233	0.016	0.075
SDI-811	B9a	*Donax gouldii*	0	-0.216	0.032	1.281	0.005	0.143
SDI-811	B10a	*Donax gouldii*	0	-0.455	0.014	1.749	0.021	0.058
SDI-811	B11a	*Donax gouldii*	0	-0.169	0.029	1.969	0.010	0.062
SDI-811	B12a	*Donax gouldii*	0	0.261	0.031	1.541	0.018	0.068
SDI-811	B13a	*Donax gouldii*	0	0.063	0.023	2.185	0.006	0.094
SDI-811	B14a	*Donax gouldii*	0	-0.416	0.034	1.646	0.023	0.055
SDI-811	B15a	*Donax gouldii*	0	-0.495	0.018	1.669	0.016	0.056
SDI-811	B16a	*Donax gouldii*	0	0.341	0.036	2.245	0.024	0.076
SDI-811	B17a	*Donax gouldii*	0	-0.504	0.041	1.862	0.018	0.038
SDI-811	B18a	*Donax gouldii*	0	0.177	0.043	2.041	0.018	0.057
SDI-811	B20a	*Donax gouldii*	0	-0.040	0.029	2.078	0.022	0.048
SDI-811	C1a	*Donax gouldii*	0	-0.420	0.045	1.354	0.025	0.040

Table 9-2. Results of Oxygen and Carbon Isotopic Analyses on 54 *Donax gouldii* Shells from CA-SDI-811 and CA-SDI-812/H

(page 2 of 2)

Site	*Sample*	*Species*	*Dist (mm)*	*Oxygen*	*S.D.*	*Carbon*	*S.D.*	*Volts*
SDI-811	C1b	*Donax gouldii*	1	-0.054	0.011	1.749	0.019	0.045
SDI-811	C1c	*Donax gouldii*	2	-0.395	0.030	1.589	0.022	0.055
SDI-811	C1d	*Donax gouldii*	3	0.009	0.043	1.525	0.018	0.071
SDI-811	C1e	*Donax gouldii*	4	-0.413	0.024	1.870	0.013	0.042
SDI-811	C1f	*Donax gouldii*	5	-0.358	0.028	1.610	0.014	0.093
SDI-811	C1g	*Donax gouldii*	6	-0.539	0.047	1.416	0.014	0.047
SDI-811	C1h	*Donax gouldii*	7	-0.576	0.015	1.817	0.012	0.048
SDI-811	C2a	*Donax gouldii*	0	-0.085	0.023	1.966	0.015	0.038
SDI-811	C3a	*Donax gouldii*	0	-0.038	0.011	1.499	0.058	0.058
SDI-811	C4a	*Donax gouldii*	0	-0.289	0.028	1.439	0.022	0.121
SDI-811	C6a	*Donax gouldii*	0	-0.842	0.037	1.528	0.017	0.052
SDI-811	C7a	*Donax gouldii*	0	-0.814	0.007	1.532	0.014	0.088
SDI-811	C8a	*Donax gouldii*	0	-0.303	0.016	1.494	0.009	0.037
SDI-811	C9a	*Donax gouldii*	0	0.338	0.030	1.670	0.021	0.078
SDI-811	C10a	*Donax gouldii*	0	-0.267	0.015	1.360	0.006	0.082
SDI-811	C11a	*Donax gouldii*	0	-0.232	0.030	1.627	0.009	0.057
SDI-811	C12a	*Donax gouldii*	0	0.226	0.015	2.093	0.013	0.053
SDI-811	C14a	*Donax gouldii*	0	-0.386	0.021	1.210	0.022	0.076
SDI-811	C15a	*Donax gouldii*	0	0.251	0.029	1.873	0.007	0.072
SDI-811	C16a	*Donax gouldii*	0	-0.200	0.015	1.755	0.028	0.070
SDI-811	C17a	*Donax gouldii*	0	-0.163	0.042	1.705	0.014	0.104
SDI-811	C18a	*Donax gouldii*	0	0.009	0.020	1.544	0.014	0.064
SDI-811	C19a	*Donax gouldii*	0	-0.098	0.028	0.915	0.018	0.068
SDI-811	C20a	*Donax gouldii*	0	0.309	0.018	2.232	0.015	0.211

Table 9-3. Incremental Oxygen and Carbon Isotopic Data for Archaeological *Donax gouldii* Shells from CA-SDI-811 and CA-SDI-812/H

Site #	*Sample #*	*Provenience*	*Dist (mm)*	*Oxygen*	*S.D.*	*Dist (mm)*	*Carbon*	*S.D.*	*Volts*
SDI-812/H	A1a	Unit 19, 140-150cm	0	0.024	0.016	0	1.953	0.019	0.034
SDI-812/H	A1b	Unit 19, 140-150cm	1	-1.141	0.037	1	2.371	0.015	0.050
SDI-812/H	A1c	Unit 19, 140-150cm	2	-0.704	0.017	2	1.352	0.018	0.052
SDI-812/H	A1d	Unit 19, 140-150cm	3	-0.066	0.026	3	1.592	0.012	0.056
SDI-812/H	A1e	Unit 19, 140-150cm	4	0.211	0.034	4	1.743	0.016	0.032
SDI-812/H	A1f	Unit 19, 140-150cm	5	-0.363	0.026	5	1.736	0.005	0.061
SDI-812/H	A1g	Unit 19, 140-150cm	6	-0.859	0.015	6	1.709	0.047	0.047
SDI-812/H	A1h	Unit 19, 140-150cm	7	-0.023	0.030	7	1.865	0.016	0.070
SDI-811	B1a	Unit 122, 50-60cm	0	-0.563	0.031	0	1.908	0.025	0.045
SDI-811	B1b	Unit 122, 50-60cm	1	0.057	0.033	1	1.940	0.006	0.047
SDI-811	B1c	Unit 122, 50-60cm	2	-0.469	0.036	2	2.066	0.014	0.064
SDI-811	B1d	Unit 122, 50-60cm	3	0.297	0.033	3	2.265	0.013	0.036
SDI-811	B1e	Unit 122, 50-60cm	4	-1.022	0.024	4	1.770	0.011	0.068
SDI-811	B1f	Unit 122, 50-60cm	5	-0.443	0.030	5	1.817	0.022	0.124
SDI-811	B1g	Unit 122, 50-60cm	6	-0.071	0.035	6	1.497	0.017	0.038
SDI-811	B1h	Unit 122, 50-60cm	7	-0.051	0.023	7	1.884	0.022	0.058
SDI-811	C1a	Unit 122, 80-90 cm	0	-0.420	0.045	0	1.354	0.025	0.040
SDI-811	C1b	Unit 122, 80-90 cm	1	-0.054	0.011	1	1.749	0.019	0.045
SDI-811	C1c	Unit 122, 80-90 cm	2	-0.395	0.030	2	1.589	0.022	0.055
SDI-811	C1d	Unit 122, 80-90 cm	3	0.009	0.043	3	1.525	0.018	0.071
SDI-811	C1e	Unit 122, 80-90 cm	4	-0.413	0.024	4	1.870	0.013	0.042
SDI-811	C1f	Unit 122, 80-90 cm	5	-0.358	0.028	5	1.610	0.014	0.093
SDI-811	C1g	Unit 122, 80-90 cm	6	-0.539	0.047	6	1.416	0.014	0.047
SDI-811	C1h	Unit 122, 80-90 cm	7	-0.576	0.015	7	1.817	0.012	0.048

Table 9-4. Incremental Oxygen Isotopic Data with Inferred Water Temperature for Calcite and Aragonite based on Horibe and Oba (1972)

Site #	*Sample #*	*Provenience*	*Dist (mm)*	*Oxygen*	*S.D.*	*Calcite (°C)*	*Aragonite (°C)*
SDI-812/H	A1a	Unit 19, 140-150 cm	0	0.024	0.016	17.72	14.54
SDI-812/H	A1b	Unit 19, 140-150 cm	1	-1.141	0.037	23.05	19.90
SDI-812/H	A1c	Unit 19, 140-150 cm	2	-0.704	0.017	21.00	17.87
SDI-812/H	A1d	Unit 19, 140-150 cm	3	-0.066	0.026	18.12	14.95
SDI-812/H	A1e	Unit 19, 140-150 cm	4	0.211	0.034	16.91	13.69
SDI-812/H	A1f	Unit 19, 140-150 cm	5	-0.363	0.026	19.44	16.31
SDI-812/H	A1g	Unit 19, 140-150 cm	6	-0.859	0.015	21.72	18.59
SDI-812/H	A1h	Unit 19, 140-150 cm	7	-0.023	0.030	17.93	14.75
SDI-811	B1a	Unit 122, 50-60 cm	0	-0.563	0.031	20.35	17.23
SDI-811	B1b	Unit 122, 50-60 cm	1	0.057	0.033	17.57	14.39
SDI-811	B1c	Unit 122, 50-60 cm	2	-0.469	0.036	19.92	16.79
SDI-811	B1d	Unit 122, 50-60 cm	3	0.297	0.033	16.54	13.30
SDI-811	B1e	Unit 122, 50-60 cm	4	-1.022	0.024	22.49	19.34
SDI-811	B1f	Unit 122, 50-60 cm	5	-0.443	0.030	19.81	16.67
SDI-811	B1g	Unit 122, 50-60 cm	6	-0.071	0.035	18.14	14.97
SDI-811	B1h	Unit 122, 50-60 cm	7	-0.051	0.023	18.05	14.88
SDI-811	C1a	Unit 122, 80-90 cm	0	-0.420	0.045	19.70	16.57
SDI-811	C1b	Unit 122, 80-90 cm	1	-0.054	0.011	18.06	14.89
SDI-811	C1c	Unit 122, 80-90 cm	2	-0.395	0.030	19.59	16.45
SDI-811	C1d	Unit 122, 80-90 cm	3	0.009	0.043	17.79	14.61
SDI-811	C1e	Unit 122, 80-90 cm	4	-0.413	0.024	19.67	16.54
SDI-811	C1f	Unit 122, 80-90 cm	5	-0.358	0.028	19.42	16.28
SDI-811	C1g	Unit 122, 80-90 cm	6	-0.539	0.047	20.24	17.11
SDI-811	C1h	Unit 122, 80-90 cm	7	-0.576	0.015	20.41	17.29

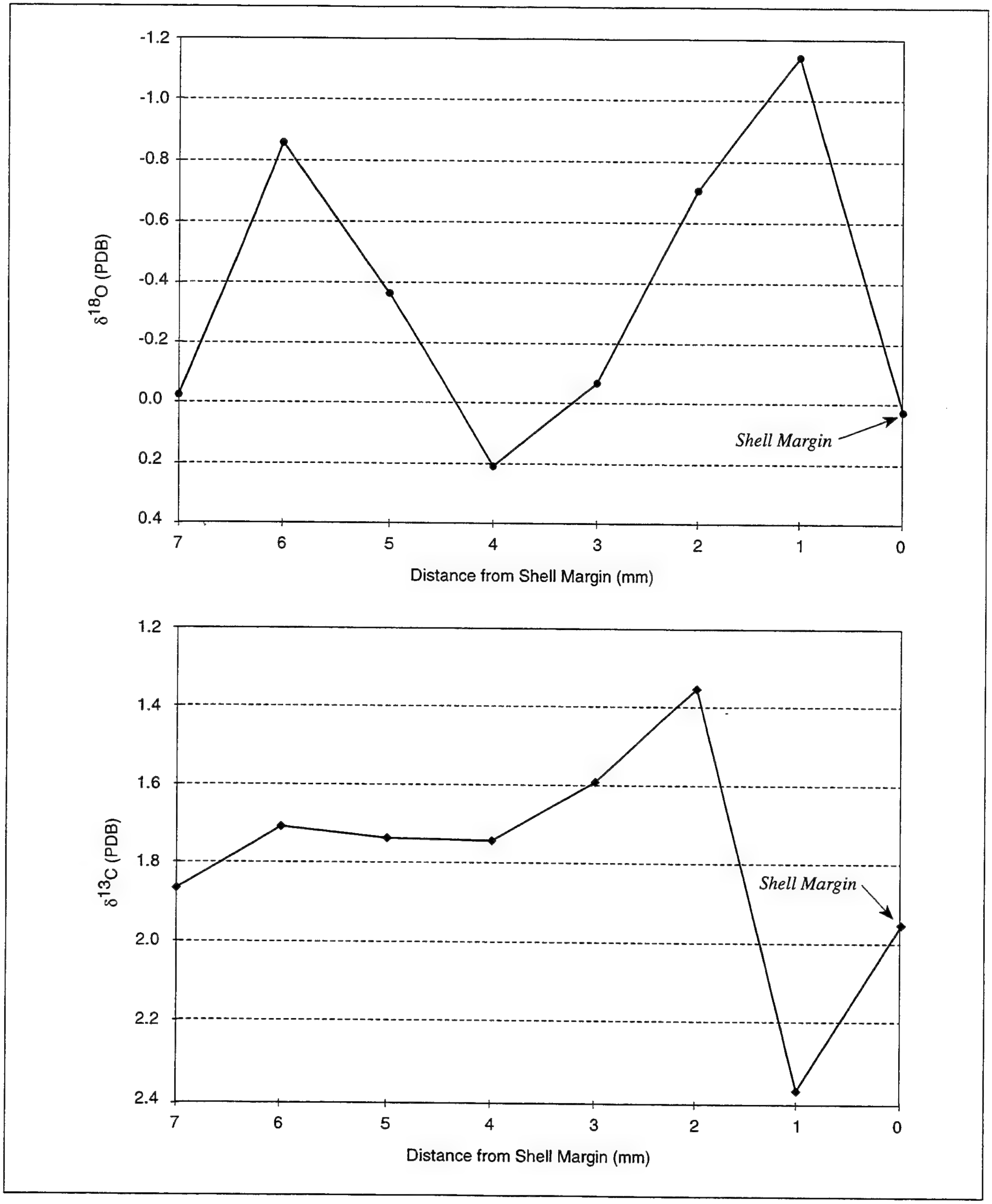


Figure 9-3. Oxygen and Carbon Isotopic Profiles for *Donax gouldii* Specimen from CA-SDI-812/H ***(Unit 19, 140-150 cm).***

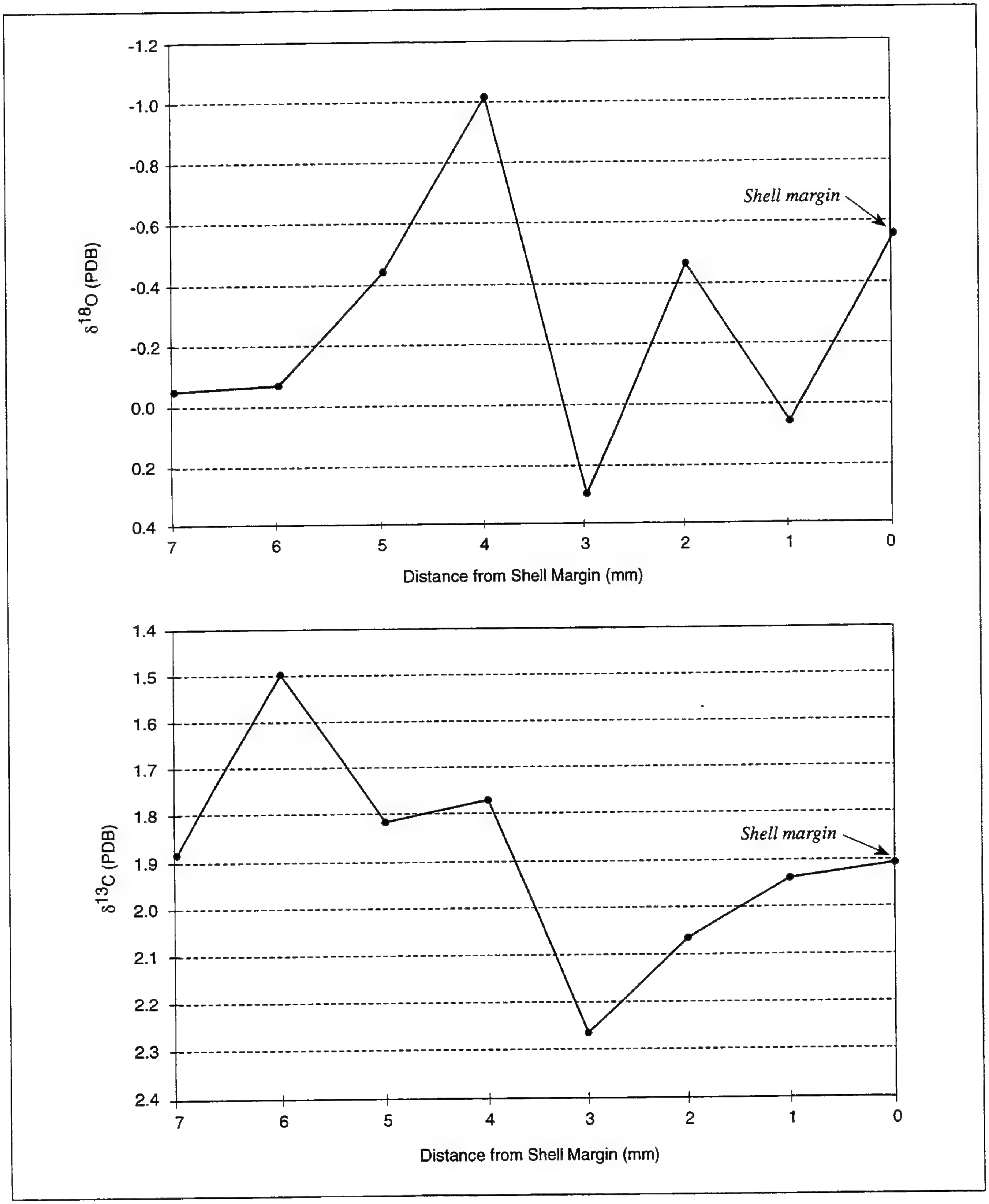


Figure 9-4. Oxygen and Carbon Isotopic Profiles for *Donax gouldii* Specimen from CA-SDI-811 *(Unit 122, 50-60 cm).*

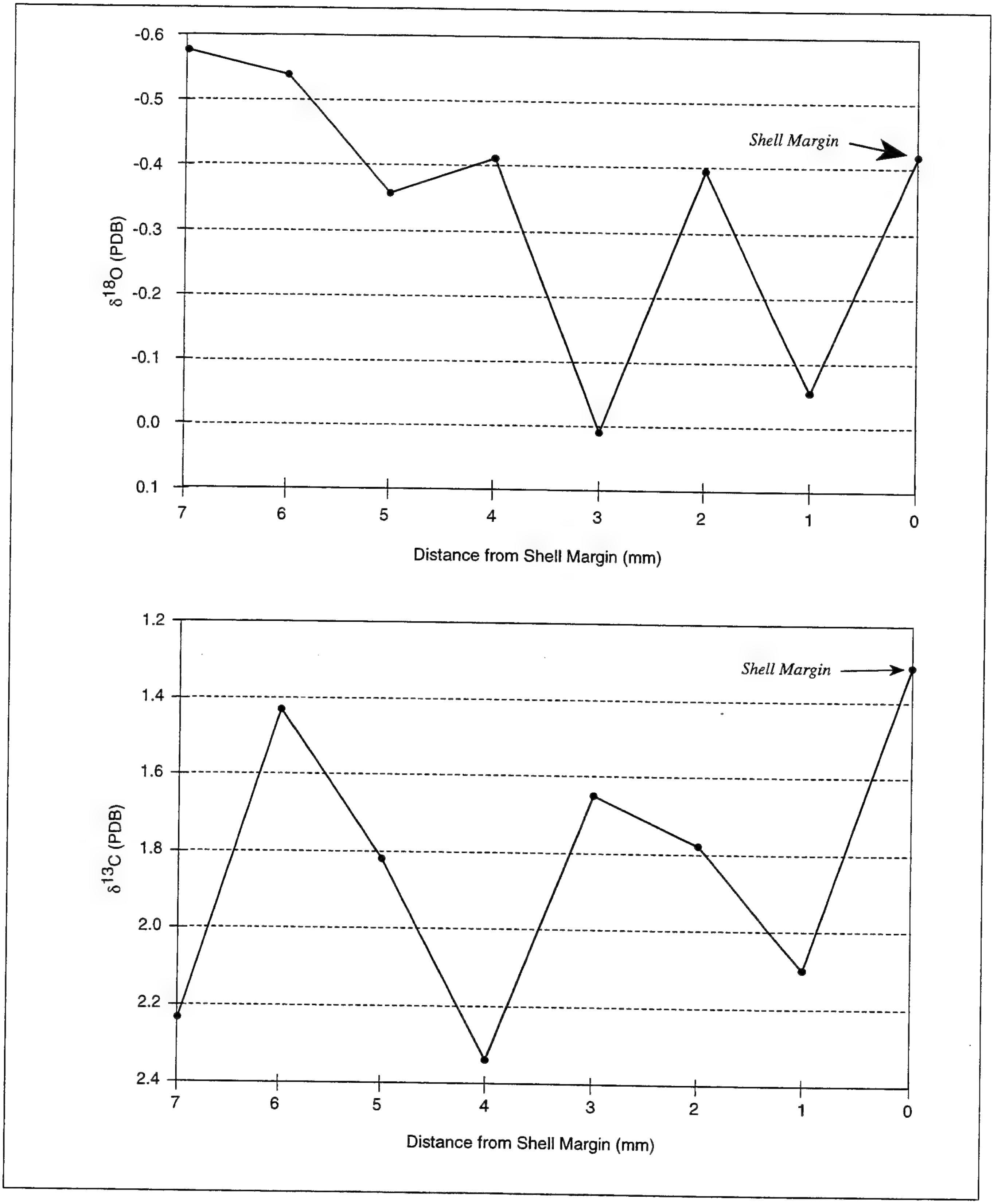


Figure 9-5. Oxygen and Carbon Isotopic Profiles for *Donax gouldii* Specimen from CA-SDI-811 ***(Unit 122, 80-90 cm).***

Table 9-5. Oxygen Isotopic Measurements of *Donax* Final Growth Increments from CA-SDI-811 and CA-SDI-812/H

(page 1 of 2)

Site #	Sample #	Species	Dist (mm)	Oxygen	S.D.	Calcite (°C)	Aragonite (°C)
SDI-812/H	A1a	*Donax gouldii*	0	0.024	0.016	17.72	14.56
SDI-812/H	A2a	*Donax gouldii*	0	-0.360	0.017	19.43	16.31
SDI-812/H	A3a	*Donax gouldii*	0	-0.784	0.015	21.37	18.26
SDI-812/H	A4a	*Donax gouldii*	0	-0.411	0.015	19.66	16.55
SDI-812/H	A5a	*Donax gouldii*	0	-0.519	0.022	20.15	17.04
SDI-812/H	A6a	*Donax gouldii*	0	-0.716	0.024	21.06	17.95
SDI-812/H	A7a	*Donax gouldii*	0	-0.390	0.020	19.57	16.45
SDI-812/H	A8a	*Donax gouldii*	0	-0.533	0.030	20.22	17.11
SDI-812/H	A9a	*Donax gouldii*	0	0.086	0.031	17.45	14.28
SDI-812/H	A10a	*Donax gouldii*	0	-0.291	0.022	19.12	16.00
SDI-812/H	A11a	*Donax gouldii*	0	-0.535	0.024	20.22	17.12
SDI-812/H	A14a	*Donax gouldii*	0	-0.791	0.047	21.40	18.30
SDI-812/H	A15a	*Donax gouldii*	0	-0.273	0.021	19.04	15.91
SDI-812/H	A16a	*Donax gouldii*	0	-0.463	0.027	19.90	16.79
SDI-812/H	A17a	*Donax gouldii*	0	-0.534	0.020	20.22	17.11
SDI-812/H	A18a	*Donax gouldii*	0	-0.797	0.034	21.43	18.32
SDI-812/H	A19a	*Donax gouldii*	0	-0.754	0.030	21.23	18.13
SDI-812/H	A20a	*Donax gouldii*	0	-0.411	0.026	19.66	16.55
SDI-811	B1a	*Donax gouldii*	0	-0.563	0.031	20.35	17.25
SDI-811	B2a	*Donax gouldii*	0	-0.175	0.030	18.60	15.47
SDI-811	B4a	*Donax gouldii*	0	0.156	0.029	17.14	13.96
SDI-811	B5a	*Donax gouldii*	0	0.120	0.012	17.30	14.12
SDI-811	B6a	*Donax gouldii*	0	-0.260	0.037	18.98	15.86
SDI-811	B7a	*Donax gouldii*	0	-0.237	0.024	18.88	15.75
SDI-811	B8a	*Donax gouldii*	0	0.260	0.033	16.69	13.49
SDI-811	B9a	*Donax gouldii*	0	-0.216	0.032	18.78	15.65
SDI-811	B10a	*Donax gouldii*	0	-0.455	0.014	19.86	16.75
SDI-811	B11a	*Donax gouldii*	0	-0.169	0.029	18.57	15.44
SDI-811	B12a	*Donax gouldii*	0	0.261	0.031	16.69	13.48
SDI-811	B13a	*Donax gouldii*	0	0.063	0.023	17.55	14.38
SDI-811	B14a	*Donax gouldii*	0	-0.416	0.034	19.68	16.57
SDI-811	B15a	*Donax gouldii*	0	-0.495	0.018	20.04	16.93
SDI-811	B16a	*Donax gouldii*	0	0.341	0.036	16.35	13.12
SDI-811	B17a	*Donax gouldii*	0	-0.504	0.041	20.08	16.97
SDI-811	B18a	*Donax gouldii*	0	0.177	0.043	17.05	13.86
SDI-811	B20a	*Donax gouldii*	0	-0.040	0.029	18.00	14.85
SDI-811	C1a	*Donax gouldii*	0	-0.420	0.045	19.70	16.59
SDI-811	C2a	*Donax gouldii*	0	-0.085	0.023	18.20	15.06
SDI-811	C3a	*Donax gouldii*	0	-0.038	0.011	17.99	14.84
SDI-811	C4a	*Donax gouldii*	0	-0.289	0.028	19.11	15.99
SDI-811	C6a	*Donax gouldii*	0	-0.842	0.037	21.64	18.53
SDI-811	C7a	*Donax gouldii*	0	-0.814	0.007	21.51	18.40
SDI-811	C8a	*Donax gouldii*	0	-0.303	0.016	19.17	16.05
SDI-811	C9a	*Donax gouldii*	0	0.338	0.030	16.36	13.13
SDI-811	C10a	*Donax gouldii*	0	-0.267	0.015	19.01	15.89

Table 9-5. Oxygen Isotopic Measurements of *Donax* Final Growth Increments from CA-SDI-811 and CA-SDI-812/H (page 2 of 2)

Site #	*Sample #*	*Species*	*Dist (mm)*	*Oxygen*	*S.D.*	*Calcite (°C)*	*Aragonite (°C)*
SDI-811	C11a	*Donax gouldii*	0	-0.232	0.030	18.86	15.73
SDI-811	C12a	*Donax gouldii*	0	0.226	0.015	16.84	13.64
SDI-811	C14a	*Donax gouldii*	0	-0.386	0.021	19.55	16.43
SDI-811	C15a	*Donax gouldii*	0	0.251	0.029	16.73	13.53
SDI-811	C16a	*Donax gouldii*	0	-0.200	0.015	18.71	15.58
SDI-811	C17a	*Donax gouldii*	0	-0.163	0.042	18.55	15.41
SDI-811	C18a	*Donax gouldii*	0	0.009	0.020	17.79	14.63
SDI-811	C19a	*Donax gouldii*	0	-0.098	0.028	18.26	15.12
SDI-811	C20a	*Donax gouldii*	0	0.309	0.018	16.48	13.27

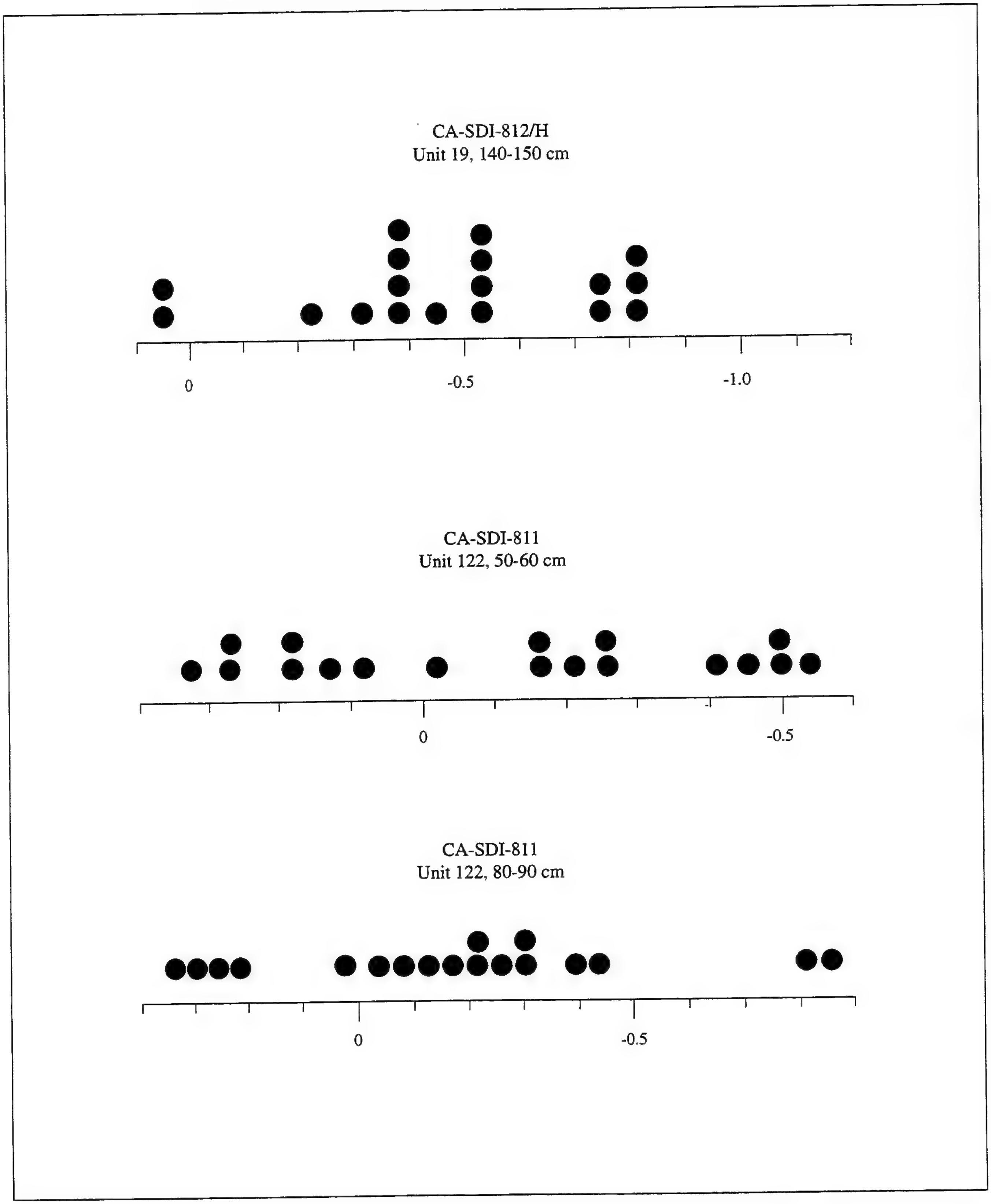


Figure 9-6. Oxygen Isotopic Measurements of Final Growth Increment Samples from CA-SDI-811 and CA-SDI-812/H

9.8 DISCUSSION

The analyses of modern *Donax gouldii*, collected at Scripps Pier, La Jolla, California, indicate that changes in the oxygen isotopic composition of shell carbonate accurately records seasonal fluctuations in sea-surface temperature (Kennett 1996). Carbon isotopic fluctuations in the same shells, thought to be indicative of upwelling intensity (Killingley and Berger 1979), appear to be random with respect to oxygen isotopic composition and less promising as a proxy for seasonal fluctuations in marine conditions. The oxygen isotopic composition of the final growth increments of modern *Donax* shells reflect the water temperature at the time of collection.

Prehistoric *Donax* shells from stratigraphic levels at SDI-811 and SDI-812/H, exhibit oxygen isotopic fluctuations similar to modern specimens. Both oxygen and carbon isotopic ratios are preserved in the incremental growth of *Donax* shells, confirming the validity of this method for reconstructing prehistoric seasonal fluctuations in sea-surface temperature and determining the season of molluscan harvesting. As in modern *Donax* shells, the carbon isotopic composition of the archaeological specimens is random with respect to oxygen and appears to have little use as a palaeoenvironmental or seasonal indicator. As a result, the following discussion is confined to the use of oxygen isotopic analysis for reconstructing sea-surface temperature and season of molluscan harvesting.

Fluctuations in oxygen isotopic composition (sea-surface temperature) are evident in the archaeological *Donax* shells. However, there is a significant difference between the maximum, minimum and average oxygen isotopic values in modern and archaeological shells (Table 9-6). In the three archaeological specimens analyzed, the oxygen isotopic values averaged -0.330‰ (19.32°C), ranging from 0.297‰ to -1.141% (16.54 to 23.05°C). Although the range in oxygen isotopic variability is comparable to the modern specimens, the oxygen isotopic ratios in the archaeological specimens from all stratigraphic units are significantly more negative (warmer).

The mean oxygen isotopic composition of modern *Donax* specimens was 0.301‰ ranging from 0.977‰ to -0.358‰ (13.68 to 19.53°C). On average, this is 0.631‰ more positive (2.77°C greater) than the oxygen isotopic values for archaeological specimens.

The geographic distribution of *Donax gouldii* along the west coast of the Americas suggests that it is a warm water species of shellfish (see Reddy 1996a). Warm water conditions could explain the prominence of *Donax* shells in the midden assemblages at SDI-811 and SDI-812/H. However, the magnitude of the oxygen isotopic shift between modern and archaeological shells should be considered tenuous due to the recent discovery that *Donax* shells are comprised primarily of aragonite. Recent work indicates that aragonite is a more unstable form of carbonate than calcite. In some depositional environments, aragonite will recrystallize to form calcite, and an associated shift in oxygen and carbon isotopic composition can occur. Also, there is some evidence that the oxygen isotopic composition of aragonite can be altered slightly if heated to temperatures above 250°C (personal communication, K.C. Lommen 1997). The standard lab procedure during the modern study was to roast all carbonate specimens at 400°C to remove organic material. Recent experiments with *Saxidomus* shells, another aragonitic clam species, indicate a slight positive shift in the oxygen isotopic values when roasted at 400°C. To avoid similar oxygen isotopic

Table 9-6. Maximum, Minimum and Average Oxygen Isotopic Values of Modern and Archaeological Shell Specimens

		Oxygen			Calcite (°C)			Aragonite (°C)		
Sample #	*Location*	*Ave.*	*Max.*	*Min.*	*Ave.*	*Max.*	*Min.*	*Ave.*	*Max.*	*Min.*
SAIC1	Scripps Pier	0.352	0.917	-0.061	16.32	18.10	13.93	13.08	14.95	10.53
SAIC2	Scripps Pier	0.250	0.977	-0.358	16.78	19.53	13.68	13.55	16.41	10.26
A1	SDI-812/H	-0.365	0.211	-1.141	19.49	23.05	16.91	16.33	19.90	13.69
B1	SDI-811	-0.283	0.297	-1.022	19.11	22.49	16.54	15.95	19.34	13.30
C1	SDI-811	-0.343	0.009	-0.576	19.36	20.41	17.79	16.22	17.29	14.61

shifts caused by high temperatures, the archaeological *Donax* specimens in this study were roasted at 200°C. Several modern *Donax* samples should be roasted at 200°C to determine if the oxygen isotopic values are truly more positive or an artifact of the roasting procedure.

The findings suggest that patterns of shellfish harvesting were different at SDI-811 and SDI-812/H. Prehistoric shellfish harvesting profiles in both levels at SDI-811 indicate that bean clams were collected throughout the annual cycle. At CA-SDI-811-B (Unit 122, 50-60 cm), the oxygen isotopic composition of final growth increment samples range from 0.341‰ (16.35°C) to -0.563‰ (20.35°C), across the full range exhibited in the oxygen isotopic profile for the same level. A similar pattern is evident in the data for CA-SDI-811-C (Unit 122, 80-90 cm). Final growth increment samples in this level also occur across the full seasonal range, however there appears to be significant gap between -0.420 (19.70°C) and-0.814‰ (21.51°C), possibly indicating cessation of bean clam harvesting during summer and/or fall months (June to October).

In contrast to the year round harvesting strategies at SDI-811, *Donax* harvesting appears to have been more seasonal at SDI-812/H. Oxygen isotopic values in the full isotopic profile for this level range between 0.211‰ (16.91°C) and -1.141‰ (23.05°C). The final growth increment samples from this level range between 0.086‰ (17.45°C) and -0.797‰ (21.43°C), but are concentrated between -0.273‰ (19.04°C) and -0.797‰ (21.43°C). Given the extended oxygen isotopic range in this specimen (compared to modern specimens) this is indicative of clam harvesting between March and June and/or November and December. Full oxygen isotopic profiles will be necessary to make such a determination.

In sum, the results presented in this study indicate that oxygen isotopic composition of archaeological *Donax* shells is preserved and reflects seasonal changes in sea-surface temperature. A large difference exists between the maximum, minimum, and average oxygen isotopic values in the modern and archaeological specimens. This could reflect (1) warm water conditions when the *Donax* middens at SDI-811 and -812 formed or (2) an isotopic fractionation effect associated with roasting temperatures above 250°C. Further experimental work is needed with modern *Donax gouldii* to develop an aragonite temperature equation. Regardless, the seasonality profiles at SDI-811 suggests year-round exploitation of *Donax*. In contrast, the bean clam harvesting profile at SDI-812/H suggests seasonal exploitation of *Donax* between March and June and/or November and December.

10 PALEOBOTANICAL ANALYSIS

Steve L. Martin
Virginia S. Popper

10.1 INTRODUCTION

A total of nine soil samples, three from two shell midden deposits (Units 109 and 122) and six from two fire-affected rock concentrations (Units 115 and 116), were collected for macrobotanical analysis (Table 10-1). The fire-affected rock concentrations appear to represent secondary refuse deposits such as the clean out of hearths and the discard of general waste. As such, all of the samples represent secondary refuse deposits. The primary objectives of this analysis were to (1) document the type and frequency of botanical remains recovered from the samples, (2) address the issue of site seasonality, and (3) compare the recovered plant assemblage to previous samples (Reddy 1996b) and other sites in the region (Popper and Klug 1992, 1995; Reddy 1996b). The nine samples were selected because they had the highest potential for yielding interpretable results.

Table 10-1. Provenience and Sample Size Information for the Analyzed Samples from CA-SDI-811

EB No. [a]	*Unit*	*Depth (cm)*	*Site Context*	*Volume (L)*
1628	109	100-110	Midden deposit (AU 3)	10.0
1629	115	40-50	FAR I (AU 4)	8.0
1626	115	50-60	FAR I (AU 4)	5.5
1630	115	60-70	FAR I (AU 4)	8.0
1631	116	40-50	FAR II (AU 5)	8.0
1627	116	50-60	FAR II (AU 5)	5.0
1632	116	60-70	FAR II (AU 5)	10.0
1625	122	50-60	Midden deposit (AU 1)	5.0
1633	122	60-70	Midden deposit (AU 1)	8.0

a. The EB number is the accession number of the UCLA Paleoethnobotany Laboratory.

10.2 METHODS

Soil samples from SDI-811 were processed in a mechanical flotation device following Watson's (1976) design and processing procedure. The flotation device consists of a 55-gallon water-filled drum with an insert screen of 0.5 mm mesh. Soil samples of known volume were slowly poured into the partially submerged insert screen. Low density carbonized botanical remains (light fraction) float to the surface and are directed out of the drum, via a sluice way, into chiffon netting (0.02 mm mesh). High density carbonized botanical remains are brought to the surface by the action of water agitation and stirring.

This procedure is performed until no carbonized plant material is seen flowing into the netting. A siphon is then used to remove any carbonized material that has become waterlogged and remains submerged (Gumerman and Umemoto 1987). Once the siphon process is completed the netting is hung to dry and the material remaining in the insert screen (heavy fraction) is set out to dry and saved for future analysis. During the flotation of sample 2 (EB-1626) the flotation machine malfunctioned resulting in the loss of an unknown amount of light fraction. Based on the charcoal and seeds densities presented below, little of the sample appears to have been lost. All heavy fractions were examined for the presence of carbonized material. The recovery rate of the mechanical flotation device has been tested using the poppy seed method (Wagner 1982) and yielded recovery rates of 90%.

When dry, the light fraction was sifted through a series of nested sieves (2.00, 1.00, and 0.50 mm), yielding four size fractions (>2.00 mm, 2.00-1.00 mm, 1.00-0.50 mm, and <0.50 mm) in preparation for sorting. The light fraction is divided as such for two reasons. It is easier to sort material of similar size, given the shallow depth of field of the incident light binocular microscope (10-40x) employed. It also allows one to selectively remove distinct materials from each fraction. In this analysis, carbonized wood was only removed from the >2.00 mm fraction and weighed. A "P" is used to indicate the presence of carbonized wood in samples which lacked any >2.00 mm in size. All other carbonized plant material was removed from the 2.00-1.00 mm and 1.00-0.50 mm fractions and counted or weighed. Material <0.50 mm in size was quickly scanned for whole carbonized seeds; however, none were present. Plant material generally decomposes in a relatively short period of time after deposition. Therefore, uncarbonized plant remains, which usually represent contamination by modern vegetation, are noted but not removed (Keepax 1977; Minnis 1981). Only carbonized material was considered cultural in this analysis.

Finally, the recovered carbonized plant remains were identified. This was achieved through the use of comparative plant and seed collections and seed manuals located in the Paleoethnobotany Laboratory in the Institute of Archaeology at UCLA.

10.3 RESULTS

Nine samples, comprising a total soil volume of 67.5 L, from two shell midden deposits (23.0 L) and two fire-affected rock concentrations (44.5 L) were analyzed. The results of the macrobotanical analysis are presented in Tables 10-2 through 10-4. Table 10-2 and 10-3 present absolute counts, absolute weights, and densities (counts/liter or grams/liter) for the recovered carbonized material. Table 10-4 presents ethnographically documented uses by coastal southern California peoples for taxa related to those recovered from SDI-811. The seasonal availability of the useful parts of the recovered taxa is also given.

Seeds are rarely identified to the species level because seeds within the same genus are often morphologically very similar and carbonization often distorts seeds, obscuring diagnostic characteristics. There were some seeds that could not be identified to genus and, based on morphology, were placed in families. These include the Fabaceae (legume) and Poaceae (grass) families. The Centrospermae category refers to the recovery of carbonized endosperm from those families in which the embryo curves around the centrally located cylindrical endosperm. All locally available species of *Marah* produce large round seeds (10-30 mm) with very thick (ca. 1.0 mm), distinct seed coats which easily fragment after

Table 10-2. Carbonized Plant Material Absolute Counts and Weight (g) from CA-SDI-811

	UNIT 109	UNIT 115			UNIT 116			UNIT 122	
Type	*100-110 cm*	*40-50 cm*	*50-60 cm*	*60-70 cm*	*40-50 cm*	*50-60 cm*	*60-70 cm*	*50-60 cm*	*60-70 cm*
SEEDS									
Atriplex sp.	–	–	–	–	–	1	–	–	–
Atriplex sp. cf.	–	–	–	–	–	–	–	1	–
Centrospermae	–	–	–	–	–	–	1	–	–
Chenopodium sp.	–	–	–	–	–	6	–	1	–
Fabaceae	–	–	–	–	–	–	1	–	–
Hemizonia sp.	–	–	–	–	2	2	–	–	–
Hemizonia sp. cf.	–	–	1	–	–	–	–	–	–
Phalaris sp.	–	–	–	1	–	–	–	–	–
Poaceae	–	1	–	–	–	1	1	–	–
Unidentifiable seeds	–	4	6	–	4	8	3	12	1
Seed Total [a]	0	5	7	3	6	18	6	14	1
PLANT PARTS [b]									
Wood	0.33	P	0.16	0.29	0.29	0.33	10.00	0.21	0.06
Quercus sp. (nutshell)	–	–	–	–	–	<0.01	–	–	–
Marah sp. (seed coat)	<0.01	–	–	–	<0.01	<0.01	<0.01	<0.01	<0.01
Amorphous	–	<0.01	–	–	–	–	<0.01	–	–

[a] Seed total includes unidentifiable seeds and fragments.

[b] P denotes the presence of wood charcoal in <2.00 mm fractions.

Table 10-3. Carbonized Plant Material Densities (counts/liter or grams/liter) from CA-SDI-811

	UNIT 109	UNIT 115			UNIT 116			UNIT 122	
Type	*100-110 cm*	*40-50 cm*	*50-60 cm*	*60-70 cm*	*40-50 cm*	*50-60 cm*	*60-70 cm*	*50-60 cm*	*60-70 cm*
SEEDS									
Atriplex sp.	-	-	-	-	-	0.20	-	-	-
Atriplex sp. cf.	-	-	-	-	-	-	-	0.20	-
Centrospermae	-	-	-	-	-	-	0.10	-	-
Chenopodium sp.	-	-	-	-	-	1.20	-	0.20	-
Fabaceae	-	-	-	-	-	-	0.10	-	-
Hemizonia sp.	-	-	-	-	0.25	0.40	-	-	-
Hemizonia sp. cf.	-	-	0.18	-	-	-	-	-	-
Phalaris sp.	-	-	-	0.13	-	-	-	-	-
Poaceae	-	0.13	-	-	-	0.20	0.10	-	-
Unidentifiable seeds	-	0.50	1.09	-	0.50	1.60	0.30	2.40	0.13
Seed Total [a]	0	0.63	1.27	0.13	0.75	3.60	0.50	2.80	0.13
PLANT PARTS [b]									
Wood	0.03	P	0.03	0.04	0.04	0.07	1.00	0.04	<0.01
Quercus sp. (nutshell)	-	-	-	-	-	<0.01	-	-	-
Marah sp. (seed coat)	<0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01
Amorphous	-	<0.01	-	-	-	-	<0.01	-	-

[a] Seed density includes unidentifiable seeds and fragments.

[b] Values are weight densities (g/L) except unknown plant part(s). P denotes the presence of wood charcoal in <2.00 mm fractions.

Table 10-4. Ethnographically Documented Uses by Coastal Southern California Peoples for Taxa Related to those Recovered from CA-SDI-811

Family	*Botanical Name*	*Common Name*	*Part(s) Used*	*Uses*	*Group*	*Season Item is Available*
Asteraceae	*Hemizonia* sp.	Tarweed	seeds	foodstuff	Chumash	
Asteraceae	*Hemizonia fasciculata*	Tarweed	whole plant	foodstuff	Cahuilla	early summer – fall
Asteraceae	*Hemizonia fasciculata*	Tarweed	whole plant	brooms	Chumash	
Chenopodiaceae	*Atriplex* sp.	Saltbush	flowers, stems, leaves	medicinal	Cahuilla	
Chenopodiaceae	*Atriplex* sp.	Saltbush	leaves, roots	surfactant	Cahuilla	
Chenopodiaceae	*Atriplex* sp.	Saltbush	seeds	foodstuff	Cahuilla	summer – early fall
Chenopodiaceae	*Atriplex californica*	Saltbush	roots	surfactant	Luiseño	
Chenopodiaceae	*Atriplex californica*	Saltbush	seeds	foodstuff	Luiseño	late spring – late fall
Chenopodiaceae	*Atriplex lentiformis*	Big saltbush	roots, leaves	medicinal	Cahuilla	
Chenopodiaceae	*Atriplex lentiformis*	Big saltbush	seeds	foodstuff	Cahuilla	summer – early fall
Chenopodiaceae	*Atriplex lentiformis*	Big saltbush	whole plant (ashes)	surfactant	Chumash	
Chenopodiaceae	*Chenopodium* sp.	Goosefoot	shoots, leaves	foodstuff	Cahuilla	spring
Chenopodiaceae	*Chenopodium berlandieri*	Pitseed goosefoot	seeds	foodstuff	Chumash	summer
Chenopodiaceae	*Chenopodium californicum*	Pitseed goosefoot	bark	medicinal	Chumash	
Chenopodiaceae	*Chenopodium californicum*	Pitseed goosefoot	roots	surfactant	Cahuilla	
Chenopodiaceae	*Chenopodium californicum*	Pitseed goosefoot	roots	surfactant	Chumash	
Chenopodiaceae	*Chenopodium californicum*	Pitseed goosefoot	roots	surfactant	Luiseño	
Chenopodiaceae	*Chenopodium californicum*	Pitseed goosefoot	sap (gum)	medicinal	Cahuilla	
Chenopodiaceae	*Chenopodium californicum*	Pitseed goosefoot	seeds	foodstuff	Cahuilla	summer
Chenopodiaceae	*Chenopodium californicum*	Pitseed goosefoot	seeds	foodstuff	Luiseño	summer
Chenopodiaceae	*Chenopodium californicum*	Pitseed goosefoot	whole plant	medicinal	Cahuilla	
Cucurbitaceae	*Marah macrocarpus*	Wild cucumber	fruit husk	magical	Chumash	spring
Cucurbitaceae	*Marah macrocarpus*	Wild cucumber	seeds	game pieces	Chumash	spring
Cucurbitaceae	*Marah macrocarpus*	Wild cucumber	seeds	medicinal	Chumash	spring
Fagaceae	*Quercus agrifolia*	Coast live oak	acorns	foodstuff	Cahuilla	fall
Fagaceae	*Quercus agrifolia*	Coast live oak	acorns	foodstuff	Luiseño	fall
Fagaceae	*Quercus agrifolia*	Coast live oak	acorns	foodstuff	Chumash	fall
Fagaceae	*Quercus agrifolia*	Coast live oak	bark	medicinal	Chumash	
Fagaceae	*Quercus agrifolia*	Coast live oak	shoots	bows	Chumash	fall
Fagaceae	*Quercus agrifolia*	Coast live oak	twigs	cradles	Chumash	
Poaceae	*Phalaris* sp.	Maygrass	seeds	foodstuff	Chumash	late spring
Poaceae	*Phalaris* sp.	Maygrass	seeds	foodstuff	Juaneño	late spring
Poaceae	*Phalaris* sp.	Maygrass	seeds	foodstuff	Gabrielino	late spring

Sources: Ball (1962), Barrows (1900), Bean and Saubel (1972), Ebeling (1986), Harrington (1978), Munz (1974), Sparkman (1908), Timbrook (1990)

carbonization. Thus, its nutshell-like fragments are grouped with plant parts in Table 10-2. Any identifications which carry some uncertainty are indicated as cf.

Seeds that are too distorted or fragmented to classify to even the family level are placed in the unidentifiable seeds category. Botanical material that lacked any diagnostic characteristics and could not be positively identified to known taxa was placed in the Amorphous category. Amorphous material is typically very porous, possesses minimal vessel structure, and lacks a distinctive shape. In many instances, the amorphous material appeared to be carbonized tree resin or bark.

The following identifiable seeds were recovered from the SDI-811 samples: *Atriplex* sp. (saltbush), *Chenopodium* sp. (goosefoot), Fabaceae (Legume family), *Hemizonia* sp. (tarweed), *Marah* sp. (wild cucumber), *Phalaris* sp. (maygrass), and Poaceae (Grass family). *Quercus* sp. (oak) nutshell was also recovered. All taxa identified have ethnographically documented uses by local Native American groups (see Table 10-4). These taxa also represent the wide range of habitats found in the vicinity of the site, including open grassland, chaparral, coastal sage, and oak savanna. Their recovery suggests the regular exploitation of these habitats by the occupants of SDI-811.

Since the soil volumes of the flotation samples varied, density values were calculated so as to allow for comparisons across all samples. The average wood charcoal density for the site was 0.2 g/L. The wood charcoal densities are consistent across all units and similar to values reported for other sites in the region (Table 10-5). Higher charcoal densities have been reported for coastal southern California sites farther north (e.g. Klug 1992, 1993), suggesting poorer preservation for other sites in the region. The average seed density for the site was 0.9 seeds/L. The seed densities for the various samples show considerable variation and mirror similar variation in average seed densities for other sites in the region. This is expected since seed densities often reflect deposit type and context. For example, seed densities for hearth samples (e.g. SDI-11,068; Table 10-5) are much higher than those that represent secondary refuse (Popper and Klug 1992, 1995). When compared to other sites the average seed density (0.9 seeds/L) at SDI-811 is relatively low and may indicate 1) poor preservation in the secondary refuse deposits, 2) seed processing was a minor activity at the site, or 3) the samples do not fully represent the range of deposits at the site. Given the normal charcoal densities and the small size and number of samples, the latter could well be the case.

Determining whether a site was occupied seasonally or year-round based solely on botanical material is rather problematic. Seeds, nuts, fruits, and bulbs frequently recovered from coastal southern California archaeological sites could have been stored and transported, potentially overrepresenting the duration of occupation. On the other hand, the edible portions of most plants in coastal southern California are only available during the spring and summer months leaving the fall and winter seasons underrepresented. That said, the items recovered from SDI-811 indicate year-round plant collection (see Table 10-4).

In comparing the recovered plant assemblage from SDI-811 to a previous investigation at this site (Reddy 1996b) some differences are noted. The same number of plant taxa (8) was recovered from each project. All taxa recovered in this analysis are reported by Reddy (1996b:298) except *Hemizonia* sp., *Marah* sp., and *Phalaris* sp. Additionally, a number of taxa

Table 10-5. Seed and Wood Charcoal Densities for Various Camp Pendleton Sites

Site	*Sample Volume (L)*	*Number of Seeds* [a]	*Average Seed Density (seeds/L)*	*Wood Charcoal Weight (g)*	*Average Wood Charcoal Density (g/L)*
SDI-811[b]	67.5	60	0.9	11.67	0.2
SDI-811[c]	63.0	40	0.6	—	—
SDI-1074	63.4	136	2.1	3.42	0.1
SDI-4411	28.0	140	5.0	1.22	<0.1
SDI-4538	61.0	95	1.6	—	—
SDI-10,726	261.8	187	0.7	—	—
SDI-11,068	6.9	102	14.8	2.79	0.4
SDI-13,325	24.7	14	0.6	0.46	<0.1

a Seed total includes unidentifiable seeds and fragments.
b Phase III (data recovery program)
c Phase II (Reddy 1996b)
Sources: Popper and Klug (1992, 1995); Reddy (1996b).

recovered by Reddy (1996b:298) were not found here, including: *Eragrostis* sp., *Heteromeles* sp., *Paspalum* sp., and *Sporobolus* sp. The *Eragrostis* sp. is notable as it is the most abundant type, comprising over 50% of the seeds recovered. That *Eragrostis* sp. has not been found in previous studies (Popper and Klug 1992, 1995) is puzzling. The difference in taxa recovered from the two SDI-811 analyses could reflect differences in identification or different processing of plants across the site. Nonetheless, the habitats and seasons represented by both assemblages are similar.

Comparing other sites in the region (Popper and Klug 1992, 1995; Reddy 1996b), there appears to be a great deal of congruence in plant assemblages both in the types and number of taxa present. This suggests similar patterns of plant exploitation; however, given the small number and size of samples taken from these sites, any conclusions concerning plant use are tentative. The only notable difference is the lack of freshwater marsh habitat species, such as *Scirpus* sp., from the SDI-811 analyses.

10.4 SUMMARY

The results from the macrobotanical analysis of SDI-811 presented here suggest moderate to poor preservation of carbonized remains and little difference between the shell midden and the fire-affected rock concentration deposits. Charcoal densities were consistent with previously reported results, whereas seed densities were relatively low. Little variation in the compared plant assemblages was noted suggesting similar patterns of plant exploitation. *Marah* sp. (most likely *M. macrocarpus*) carbonized seed coat fragments are found in 65 percent of the samples from SDI-811 and are regularly recovered from coastal southern California archaeological sites. All ethnographic accounts indicate that *Marah* had medicinal and ceremonial functions none of which required heat treatment. Why it is so ubiquitous remains a mystery. The other taxa recovered were all locally available, have recorded uses by historic Native American groups, and probably represent food resources.

11 SETTLEMENT AND SUBSISTENCE ORGANIZATION WITHIN LAS FLORES CREEK

Karen A. Rasmussen

11.1 INTRODUCTION

The purpose of this project was to conduct a data recovery investigation of the Red Beach site, SDI-811. During the investigation, we discovered cultural deposits ranging in age from 2400 B.C. to as recent as A.D. 1000. These deposits provide important information about a little known time period, the latter part of the Archaic and the early part of the Late Prehistoric of the coastal area of Las Flores Creek.

A summary of our findings, including a basic interpretation of site function, is provided below. The Red Beach site is then compared to other sites in the Las Flores Creek region in order to explore how settlement and subsistence patterns changed over time.

11.2 THE RED BEACH SITE

Site Structure and Cultural Material

The Red Beach site consists of an extensive Archaic/Late Prehistoric archaeological deposit within an alluvial fan formed at the mouth of Las Flores Creek. Cultural material lies along the ground surface throughout much of the designated site area; however, densities of both surface and subsurface deposits are greatest in the southeast portion of the site.

Various natural and cultural disturbances have affected the integrity of the upper-most deposits. Rodent activity and root penetration have led to some mixing of the upper soil horizons while several dirt roads created by tank travel have affected some surface areas. In addition, historic farming activities created a plowzone, which correlates roughly with the top 40 cm of soil. Despite the various types of disturbance, the site retains good vertical and horizontal integrity, especially below 40 cm in depth.

The bulk of the archaeological material was recovered within intact deposits located under the plowzone, 40 to 150 cm below the surface. The majority of the recovered material consisted of shellfish, animal bone, flaked stone, and fire-affected rock. Tizon Brownware, groundstone, shell and bone beads, tarring pebbles, and botanical remains were also recovered in lessor amounts.

The vertebrate assemblage represents a diversified subsistence strategy that used a wide range of resources from the immediate and nearby areas. The assemblage displayed a fair

amount of diversity for its sample size and included marine (fish, sea otter, pinniped), freshwater (pond turtle), and terrestrial resources (deer, coyote or dog, jackrabbit, cottontail or brush rabbit, ground squirrel, pocket gopher, woodrat). The fish assemblage consists of at least 13 mutually exclusive taxa from sandy bottom, rocky bottom, and open water habitats.

The highly diversified invertebrate assemblage consists of 18 mutually exclusive taxa from a wide range of habitats. Despite the high diversity, only a few species (bean clam, Venus clams, scallops) dominate the assemblage in terms of abundance. The overall assemblage indicates a pronounced emphasis on the exploitation of sandy shores with a moderate exploitation of bays and/or marine estuaries. Rocky shore species are present, but only in low numbers.

Botanical remains were recovered through the flotation of selected column samples. The botanical assemblage includes saltbush, goosefoot, the Legume family, tarweed, wild cucumber, maygrass, grass family, and oak. These taxa represent a wide range of habitats available locally, including open grassland, chaparral, coastal sage, and oak savanna. According to the ethnographic record, all of the various identified plant taxa were known to have been exploited by Native American groups and most were used for food.

The flaked stone assemblage consists of 3,311 artifacts. Over 98 percent of the assemblage was composed of debitage, while the remaining 2 percent include 26 cores, 17 utilized flakes, 12 unifacially retouched flakes, and 9 percussing tools. The lithic raw material — volcanic cobbles, quartz, quartzite, granitic material, chert, and metamorphic rock — came primarily from local sources. The goal of most manufacturing sequences represented at the site appear to have been the production of large flakes, not formal tools. The apparent preference for large flakes suggests that people were conducting tasks that required strong pressure or force, such as shaping wood or bone.

Review of the Five Analytic Units

The distribution of cultural material displays strong horizontal, vertical, and temporal patterns. The southeast portion of the site contains higher densities of material, in general, than those further in the northwest. In addition, the deposits within the southeast portion display strong localized spatial patterns. In order to better understand the spatial and temporal variations at the site, five analytic units — representing five different occupational episodes — were defined based on soil stratigraphy, cultural material encountered, and radiocarbon dates.

The five analytical units (AUs) consist of three distinct midden deposits and two fire affected rock scatters. AU 1, composed of material from 0-70 cm in depth within Units 100 and 122, is a dense midden deposit dominated by *Donax* remains. The deposit dates to the Late Prehistoric period, approximately A.D. 700-900. The extremely high density of shellfish remains and clear dominance of the assemblage by *Donax* led to the hypothesis that this area of the site had been the center of specialized *Donax* processing during this time period. At first, the low density of animal bone recovered from AU 1 seemed to support this interpretation. The vertebrate assemblage, however, is composed of a wide variety of animal species, including pinniped, turtle, fish, and various-sized terrestrial mammals. In terms of flaked stone material, AU 1 has a relatively diverse assemblage and contains a large

number of early stage core reduction flakes. The wide diversity of animal species encountered and the presence of a relatively diverse stone tool assemblage suggests that AU 1 represents a short-term residence area instead of simply a specialized shellfish processing station.

AU 2, a light midden deposit, is composed of the upper layers (0-60 cm) of Unit 109. Based on radiocarbon dates from deeper layers, the material of AU 2 represents a Late Prehistoric occupation, dating sometime after A.D. 150. AU 2 has the lowest density of invertebrate remains and moderate densities of vertebrate remains and flaked stone material compared to the rest of the analytical units. All size classes of terrestrial mammals are represented as well as four distinct species of fish, but only one type of shellfish (*Donax*). As for flaked stone material, AU 2 contains a relatively low density of material representing a narrow range of debitage stages and only two formal tools. AU 2 appears to represent a short-term occupation emphasizing the exploitation of small mammals and fish.

AU 3, another midden deposit, is composed of the lower levels (90-150 cm) of Unit 109. This deposit dates to the transitional period between the Archaic and Late Prehistoric, approximately 20 B.C. to A.D. 150. Unlike the upper layers of this unit (AU 2), the lower levels contain relatively dense cultural deposits. The faunal assemblage of AU 3 demonstrates a mixed hunting strategy of large and small terrestrial game as well as a strong emphasis on the exploitation of fish. In terms of flaked stone material, AU 3 contains a relatively low density of material representing a narrow range of debitage stages and no formal tools. The wide range and moderate densities of cultural material suggest that AU 3 was produced by a longer duration of occupation than the upper deposit of this unit (AU 2).

AU 4 and AU 5 represent distinct fire-affected rock scatters. AU 4 (FAR I) dates to the Archaic period, around B.C. 1200-835, while AU 5 (FAR II) dates to the transitional period between the Archaic and the Late Prehistoric, around B.C. 210-20. The most obvious characteristic of these two areas was broad scatters of burnt rock mixed with various stone tools and faunal material. Although the two areas differed in the amount of fish and shellfish recovered, both areas had relatively high densities of mammal bone, representing a mixed marine/terrestrial resource base. The two AUs had the highest density and diversity of flaked stone tools and debitage. The two deposits were probably the result of hearth clean-outs in the nearby area. The contrasting faunal signatures, in terms of fish and shellfish, suggest that the two areas may have been used for slightly different purposes or that there had been a change in dietary strategy between the two time periods represented.

Season of Occupation

Seasonality data is very useful for understanding what part of the year an archaeological site was occupied and its place in the annual round. Was it only used during the summer months or were people living there for most of the year? These questions are useful not only for understanding the purpose of the site itself but also how it fits into the general settlement and subsistence regime of the people who lived there.

Determining season of occupation is one of the more difficult tasks to accomplish, especially for a coastal site. Most types of coastal vertebrate and invertebrate resources are available year-round and offer no indication of season of exploitation. In addition, many edible

portions of plants could have been stored and transported, potentially overrepresenting the duration of occupation. On the other hand, the edible portions of most plants in coastal southern California are only available during the spring and summer months leaving the fall and winter seasons underrepresented.

Evidence for season of occupation at the Red Beach site is limited. The botanical remains from AU 1 and AU 5 represent a variety of seasons – spring, summer, and fall – probably indicating year-round plant collection activities. AU 3 and AU 4 contain seeds available in the spring or late spring only.

Faunal remains provide further evidence of seasonality. AU 1, AU 4, and AU 5 contain pinniped remains, which may represent summer occupations if such hunting was focused during the season when fur seals and sea lions were on land in rookeries and easier to kill. AU 4 also had the only fragment of a juvenile deer, suggesting occupation in the fall or early winter. Faunal material from previous excavations at the site offers additional seasonal indicators. Fish otolith analysis of samples taken from deposits roughly contemporaneous with AU 1 (A.D. 500-900) suggest occupations from March to October (Byrd et al. 1996). Although most of the fish species would have been available throughout the year, barracuda and some of the other taxa from this time period would be consistent with a spring to fall occupation.

Finally, a relatively new technique, oxygen isotope analysis of shellfish remains, was employed to determine the season of death of various bean clams recovered from two deposits at the Red Beach site. This technique takes incremental samples along a shell's growth axis and measures the oxygen isotopic ratios of each sample. These ratios are directly related to the seasonal temperature change of the local ocean waters throughout the life of the animal. Readings from the terminal growth margin of a shell indicates the sea temperature at the time the mollusc was collected, and this sea temperature correlates with season of death. The isotope analysis of *Donax* samples from AU 1, roughly A.D. 700-900, indicate that bean clams were collected throughout the year while samples taken from a deposit dating to roughly A.D. 200 to 600 display a possible cessation of bean clam collecting from June through October.

Overall, the various time periods represented at the Red Beach site contain evidence of multiple seasons of occupation.

Duration of Occupation and Re-Occupation

The multiple strands of evidence from the Red Beach site indicate that the site was occupied during various seasons of the year. In fact, the seasonal indicators suggest that local resources were exploited throughout the year. Was the site used as a year-round residential base? A permanent or semi-permanent residential site should yield relatively high densities and diversities of artifacts and features, a complex site structure including specialized activity areas and, possibly, evidence of habitation structures (Kelly 1992; O'Connell 1987; Price and Brown 1985), among other archaeological indicators.

The site structure of the Red Beach site is very complex, with considerable spatial variability. The discrete horizontal deposits lie in approximately the same depth across the site, and

these deposits appeared to be, at first glance, discrete activity areas from a single, long-term occupation. This turned out not to be the case. Extensive radiocarbon dating indicates the spatial variability reflects multiple episodes of re-occupation, rather than a single occupation of relatively long duration. This finding is consistent with other evidence; the site lacks high density and diversity of cultural materials one would expect to find in a permanent or semi-permanent habitation.

The site appears to have been used primarily as a short-term residential area that was frequently re-occupied over a long period of time. The range of animal species exploited, especially the presence of deer and rabbit, demonstrate that the site was used for more than just collecting nearby fish and shellfish. The density of bone, diversity of taxa, range of local habitats exploited, spatial patterning of bone remains, and seasonal evidence are consistent with short-term residential use of the site. The moderate density and diversity of flaked stone material, compared to other sites in the area, in conjunction with the presence of only a few bone artifacts, argue against long-term or year-round occupation.

The Red Beach site was occupied repeatedly over time, during various seasons of the year, for usually short lengths of stay. As we will see in the next section, the focus of the site occupations may have changed over time in relation to shifts in the diet of the local inhabitants.

Shifting Patterns through Time

The Red Beach site has been re-occupied over an extensive period, from 2400 B.C. to A.D. 1000. Various portions of the site were used during different time periods, and some specific locations were re-occupied. Because of its long history of re-occupation, the Red Beach site allows us to explore changing patterns in the overall settlement and subsistence system in the region of Las Flores Creek. The artifact assemblage and the botanical remains from the site were fairly consistent across time so the emphasis of this section will be placed on possible subsistence changes through time.

The oldest deposit dates back to the middle of the Archaic Period, around four thousand years ago. Cultural material included shellfish, animal bone, and possible debitage recovered from an A horizon soil buried approximately two meters below the ground surface. Not much is known about this occupation because the deposit was below the area being affected by the pipeline project and only a limited number of archaeological samples could be collected. The shellfish samples were dominated by rocky-shore invertebrates suggesting that rocky-shore habitats were still available in the local area during this time period.

The rest of the deposits date to the latter part of the Archaic and the early part of the Late Prehistoric, approximately 1200 B.C. to 1000 A.D. The invertebrate assemblage dating to the Archaic period (AU 4) was low in density with a fairly small range of species present. Density and diversity of species increased during the transition between the Archaic and Late Prehistoric (AU 3 and AU 5). The Late Prehistoric invertebrate assemblages contained the highest density and some of the highest diversity of shellfish species relative to the rest of the site (AU 1).

As for the vertebrate assemblage, all time periods display a mixed hunting strategy incorporating the use of both coastal and terrestrial resources from a wide variety of habitats. Marine mammal exploitation, however, appears to have been more important during the Archaic period than during later occupations. In addition, fish densities and diversity were the highest during the transitional Archaic/Late Prehistoric period and decrease during subsequent occupations of the site.

Overall, the assemblages from the Red Beach site suggest that there was a shift away from marine mammals and toward an increased emphasis on the exploitation of fish and/or shellfish during the Late Prehistoric. This general pattern may represent a change in diet over time by the local inhabitants. Alternatively, the increased density and diversity of fish and shellfish may correlate with a longer duration of occupation at the site instead of changes in the overall diet.

How does this general pattern match with previous reconstructions of the two time periods? According to the cultural reconstructions outlined in Chapter 2 (e.g., Bull 1987; Ezell 1987; Moriarty 1966; Warren 1987), there was a dietary shift during the Archaic Period from generalized hunting and gathering to an increased reliance on marine resources, particularly shellfish and fish. The Late Prehistoric represents a shift from littoral resource exploitation to an emphasis on inland plants, especially acorns, and these changes are believed to be associated with a migration of Yuman speaking and/or Shoshonean peoples (see Chapter 2). The information from the Red Beach site, however, offers a slightly different timing for these events. According to the new information from the site, the shift toward fish exploitation appears to occur during the transitional Archaic/Late Prehistoric Period, at the same time that marine mammals lessen in importance. Intensive shellfish harvesting, especially of *Donax*, does not begin until subsequent Late Prehistoric occupations. The botanical remains are too few to characterize changes through time, but it is interesting to note that the only oak nutshells were recovered from AU 5, which dates to the transitional Archaic/Late Prehistoric time frame.

11.3 LAS FLORES CREEK SETTLEMENT & SUBSISTENCE PATTERNS

Review of Settlement Models

How does the Red Beach site fit into the local settlement and subsistence system based in the Las Flores Creek area and how has this system changed over time? Various models have been proposed that attempt to outline the structure of settlement and subsistence strategies of hunter/gatherers living in the Camp Pendleton region. Most are based on ethnographic reconstructions of Luiseño or Juaneño patterns (e.g., Bean and Shipek 1978; Shipek 1977). The problem with many of these models is that little ethnohistoric information exists about coastal occupations because coastal areas were the first impacted by the Spanish (e.g., Kroeber 1925; Sparkman 1908). The exact nature of settlement dynamics of the Luiseño, therefore, is still debated.

According to Bean and Shipek (1978), the Luiseño exploited a wide range of resources in a bi-modal seasonal system. Most inland groups had fishing and gathering sites on the coast that were visited annually when the tides were low or when inland foods were scarce from

January to March. The mountain camp was occupied by most of the village population during October and November when acorns were harvested and game animals hunted. It has also been suggested that coastal Luiseño and Juaneño groups stayed along the seashore the entire year instead of utilizing Bean and Shipek's bi-modal system (Koerper 1981). Alternatively, Shipek (1977) suggests that the Luiseño occupied permanent villages in a variety of ecological zones and made seasonal forays to procure specific resources from particular localities.

The ethnographic record reflects a time when indigenous lifeways had already been affected by Spanish contact and Missionization, and it may not accurately portray pre-contact times. Even if one of the above models accurately describes ethnohistoric lifeways, settlement and subsistence strategies had certainly changed from earlier times, partly due to the condition of the local environment. For example, the Holocene era has been a time of rapid change in terms of the structure of paleocoastlines and the representation of local flora and fauna. The rapid sea level rise during the Late Pleistocene and Early Holocene created mainly rocky shorelines along the coastal zone of Camp Pendleton (Byrd et al. 1996; Inman 1983). When the rate of the rising ocean slowed during the last 4,000 years, large expanses of sandy beach replaced most of the rocky shorelines (Inman 1983). The abundance of many types of fish and shellfish would have changed depending on what habitats were available in the local landscape. In addition to differences in the structure of the coastline, palynological studies in the Las Pulgas Canyon have demonstrated considerable change in the local plant communities over the last 4,000 years (Byrd et al. 1996). The various paleoecological developments during the Holocene would have had profound effect on the local hunters and gatherers because the types of flora and fauna available in the local region would have varied depending on the structure of local habitats at the time.

Which brings us back to our original question, how have settlement and subsistence patterns changed over time? Warren proposed that people first clustered around bays and estuaries during the early Holocene, and shellfish played a major role in the diet while hunting and fishing were considered more minor resources (Warren 1964). According to Warren, rising sea levels caused silting of the bountiful lagoons and estuary areas causing the population to move inland and intensify their exploitation of terrestrial resources. The coast was either abandoned or subject to only seasonal, short-term occupation. Byrd et al. (1997), however, have clearly demonstrated that the Camp Pendleton coastline was never abandoned and that people regularly exploited coastal resources even after sea levels rose and changed the coastal landscape.

Hudson has synthesized the core of alternative models attempting to explain the role of the coast in local settlement systems as follows:

> (1) the use of coastal sites on a limited seasonal basis, either in the winter or in the summer, by people with more permanent residences located inland and a subsistence focus on acorns, seeds, and terrestrial game; (2) the use of a variety of coastal sites on a semi-permanent basis by people who made seasonal forays into other habitats, including inland oak groves, but for whom coastal resources such as shellfish, fish, and sea mammals were of major subsistence importance; (3) the use of specific coastal sites, located adjacent to bays or lagoons with a combination of saltwater marsh and

> freshwater marsh habitats, on a semi-sedentary basis in combination with the use of other coastal locations for more temporary sites; and (4) combinations of these use patterns, with use of coastal sites on both a semi-permanent and a short-term seasonal basis, by both coastal groups and inland groups (Byrd et al 1996:241).

In order to determine how settlement patterns may have changed over time, evidence from other local sites are reviewed in the following section.

Review of Other Sites within the Las Flores Creek Locality

Certain problems were encountered when trying to compare the various sites within the coastal area of Las Flores Creek. Our goal was to construct basic density and diversity measures for the various types of cultural material from the sites or site components and to evaluate them with regards to site function and changes through time. Differences in density and diversity of cultural material may relate to differences in duration of occupation, resource zones exploited, site function, number of occupants, and disposal patterns. This type of information, along with seasonality data, is essential for reconstructing changes in the settlement/subsistence systems over time.

We compiled information from various reports that detailed the investigations of archaeological sites within the Las Flores Creek locality (e.g., Bull 1975; Byrd et al. 1996, 1997; Cagle et al. 1995, 1996a, 1996b; Carrico 1996; Ezell 1975). We encountered a number of problems, however, when we tried to calculate comparable density and diversity measures. It was sometimes difficult for the researchers to separate distinct temporal deposits at some of the sites, especially the multiple components of Locus A from SDI-10728. Lumping of different occupations could lead to an aggradation of the data, including creating inflated densities, diversities, and seasonal indicators. In addition, published data was not always in the proper format for constructing densities. For example, it was difficult to separate vertebrate remains from the various components at SDI-10726 based on the tables given in the report. Finally, the amount of testing at the sites varied considerably as did sampling strategies for analyzing the recovered cultural material. All of these factors would have affected any type the quantitative comparison between the sites. In light of these problems, the following discussion is kept at a general, qualitative level. The sites or site components are organized below in chronological order.

Archaic Sites and Components. Hunter/gatherers have occupied the coastal area of Las Flores Creek since Early Archaic times. The oldest occupation, to date, is from SDI-10728 Locus A (Byrd et al. 1997), which has calibrated dates ranging from BC 6415 to 4665 (see Table 1-2). Radiocarbon dates reported in this section will based on the 2-sigma calibrated results unless otherwise noted. The site is situated along the crest of a ridge northeast of SDI-811 (Figure 11-1). Locus A actually represents a somewhat mixed deposit of Early Archaic and Late Prehistoric components. The mixed deposit in the upper layers of the locus is dominated by *Donax* remains while a lower, unmixed Early Archaic deposit primarily contains *Chione* and *Argopecten* along with a moderate range of artifacts, vertebrate remains, and macrobotanical material. The vertebrate remains, represented by birds, fish, small mammals, and large mammals, reflect a mixed hunting/fishing strategy. The Early Archaic occupation revolves around the exploitation of bay and estuary settings along with

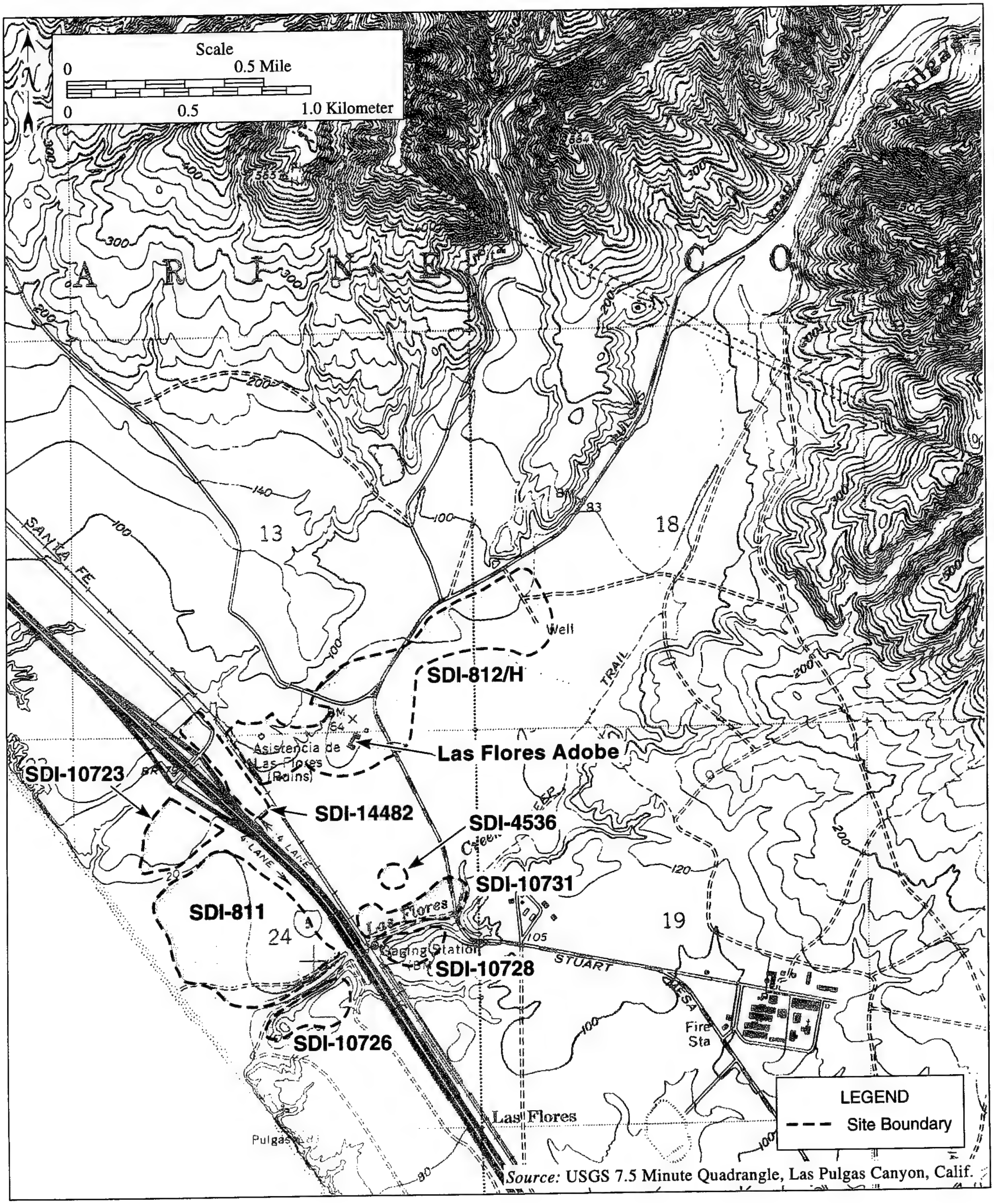


Figure 11-1. Location of Archaeological Sites in the Las Flores Creek Area

some use of rocky shore habitats and terrestrial areas. The site also yielded strong evidence for multiple seasons of occupation including fall and/or winter (Byrd et al. 1997). We believe that the site had been used as a short-term base camp during the Early Archaic period based on the density and diversity of cultural material represented.

The second Early Archaic occupation documented for this area is very similar to the one described above. The lower deposit at SDI-10726 Locus B (Byrd et al. 1996) has a calibrated range of B.C. 5520 to 5100. The site is located along a ridge overlooking the Las Flores Creek and SDI-811 and lies southwest of SDI-10728 (Figure 11-1). The upper deposit of Locus B dates to the Late Prehistoric, however, the lower component is clearly associated with the Early Archaic. The lower component contains a diverse range of terrestrial animal and plant remains as well as a variety of nearshore shellfish and fish species, especially from bay and estuary settings. The density and diversity of cultural material suggests that this area had been used as a base camp during the Early Archaic period (Byrd et al. 1996).

The cultural deposit found in the deeply buried A horizon soil at SDI-811 is currently the only local component dating to the middle part of the Archaic Period, with a calibrated range of B.C. 2405 to 1890 (see Table 5-11). The small samples retrieved from the deposit suggest that rocky-shore species were being exploited during this time period. The discovery of this deposit clearly demonstrates the existence of buried cultural deposits in alluvial contexts and the potential for future finds.

The majority of the cultural deposits from SDI-811 represent the end of the Archaic and the transition into the Late Prehistoric (1200 B.C. to A.D. 1000). These components have been fully described at the beginning of this chapter. In summary, the site appears to have been used primarily as a short-term residential area, with repeated occupations over time during various seasons of the year. Occupants utilized a wide range of coastal and terrestrial resources from numerous local and inland habitats.

Late Prehistoric/Ethnohistoric Sites and Components. The rest of the investigated archaeological sites from Las Flores Creek date to the Late Prehistoric and/or Ethnohistoric Periods. The upper component of SDI-10726 Locus B (Byrd et al. 1996) yielded two dates with calibrated ranges of A.D. 875-1025 and A.D. 1420-1660. The upper component was restricted to the western portion of the locus while the lower Early Archaic component was much more extensive in area. The upper Late Prehistoric component of Locus B is characterized by dense concentrations of *Donax*, *Argopecten*, and *Chione* as well as prehistoric ceramics, flaked stone artifacts, and some groundstone and fire-affected rock. Animal remains from the upper and lower components of Locus B represent a mixed hunting and fishing strategy. The relative frequency of fish increases while small mammals decrease between the two deposits. In addition, the high density of *Donax* remains are only associated with the Late Prehistoric component.

Locus A of SDI-10726 dates to A.D. 1015-1285 (Byrd et al. 1996). This locus can be found slightly downslope from Locus B, at the west end of the ridge. The deposit is composed primarily of *Donax* along with small amounts of animal bone, flaked stone artifacts, groundstone, and fire-affected rock. This deposit may represent a specialized *Donax* processing and consumption site; however, this designation would not fully explain the existence of the other types of cultural material.

The upper component of Locus A from SDI-10728 ranges from A.D. 1230 to 1435 (Byrd et al. 1997). This component is more difficult to define because much of it has been mixed with Early Archaic cultural material. The Late Prehistoric material is centered in the eastern half of the locus while the lower, Early Archaic deposit is much more extensive in area (similar to the pattern from Locus B at SDI-10726). The main difference between the upper and lower components was the presence of *Donax* remains associated with the Late Prehistoric occupation.

SDI-10723 yielded dates ranging from A.D. 1275 to 1835 (Cagle et al. 1996a). It is located on a marine terrace overlooking SDI-811 and the mouth of Las Flores Creek. The site is composed primarily of *Donax* remains as well as sparse to moderate amounts of flaked stone artifacts, bone, fire-affected rock, and prehistoric ceramics. The site also appears to contain multiple, horizontally discrete occupations (Cagle et al. 1996a).

SDI-14482 lies on the northeast side of Interstate 5 by the Las Pulgas turn-off. It dates between A.D. 1320 and 1680 (Cagle et al. 1996a). The site consists of mainly redeposited cultural material as well as one small area of intact deposits containing high densities of *Donax* as well as sparse to moderate amounts of flaked stone, vertebrate remains from a moderate range of species, and fire-affected rock.

Locus B of SDI-10728, lying slightly downslope from the much larger Locus A, dates between A.D. 1375-1675 (Byrd et al. 1997). This Late Prehistoric locus is composed primarily of *Donax* remains along with smaller amounts of animal bone, plant remains, flaked stone artifacts, groundstone, shell beads, and fire-affected rock. Although the high density of *Donax* remains suggests an intensive exploitation of sandy-shore habitats, the vertebrate remains represented by small mammals, large mammals, bird and fish, demonstrate that a wide variety of habitats were being exploited.

SDI-812/H is a large, sprawling site composed of 5 distinct loci, two of which are directly associated with historic occupations at the Las Flores *Estancia* and the Las Flores Adobe ranch house (Cagle et al. 1996b). The site is located on the Las Flores Creek floodplain north of Interstate 5. The earliest component of the site dates to the Late Prehistoric/Ethnohistoric periods, with radiocarbon dates around A.D. 1500 to 1800 (1 sigma-calibration). The material dating to this time period comes from a buried component within Locus C, approximately 140-180 cm below the surface. The buried component has high density and high diversity of cultural material, including bifaces and other flaked stone material, vertebrate remains, marine shell, and prehistoric pottery. The animal bone is dominated by rabbits and other small game while the invertebrate assemblage consists primarily of *Donax*. The deposits appear to represent a pre-contact Luiseño residential base (Cagle et al. 1996b).

The final two sites, CA-SDI-4536 and CA-SDI-10731, are the only ones in the coastal drainage with human interments. Both sites are located in the alluvial fill on the opposite side of Interstate 5 from the ocean (see Figure 11-1) and may have been originally part of the Red Beach site. According to ASM Affiliates (1996), the differentiation of the surface deposits into three discrete site locations may be a product of modern development, especially the construction of the Old Coast Highway and Interstate 5.

CA-SDI-4536, the Las Flores Cemetery Site, was discovered in 1973 during construction of a wildlife sanctuary (Ezell 1975). Subsequent testing documented the existence of fourteen human burials, four hearth cobble features, and a buried cultural midden deposit containing flaked stone artifacts, stone bowls, pestles, mortars, shellfish, and projectile points (Ezell 1975). A recent review of the data (Carrico 1996) suggests that the burials date to the Late Prehistoric period.

CA-SDI-10731 is primarily a *Donax* shell scatter with associated artifacts, and two human burials were discovered during grading (ASM Affiliates 1996; Bull 1975). No detailed report was prepared during the grading project, but condition evaluation concluded that although construction activities and recent flooding have heavily impacted the site, intact buried deposits probably still exist at the site (ASM Affiliates 1996). The presence of high amounts of *Donax* at CA-SDI-10731 suggests that it dates to the Late Prehistoric period.

Las Flores Creek Settlement through Time

What do these sites tell us about settlement and subsistence organization within Las Flores Creek? People have occupied this area since the Early Archaic and have utilized a mixed subsistence strategy emphasizing bay and estuary habitats for shellfish and fish exploitation. They also hunted terrestrial mammals of various size-classes. It appears that people utilized ridgetop areas as short-term base camps during multiple seasons. More Early Archaic sites probably exist along the floodplain, but have been deeply buried by alluvial sediments.

The limited information about the middle portion of the Archaic Period makes it difficult to reconstruct what people were doing in the area. At this point, all we know is that some people occupied the alluvial floodplain and exploited rocky-shore habitats. Hopefully, more sites will be discovered that date to this time period so that this temporal void can be filled.

The latter part of the Archaic and the transition into the Late Prehistoric Period is solely represented by the various components at the Red Beach site (SDI-811). People utilized the alluvial floodplain as a short-term residential base, and re-occupied the same area during various seasons of the year. People still applied a mixed hunting strategy of both marine and terrestrial resources. Marine mammal exploitation appears to have been more important during the Archaic period while fish and shellfish densities increased into the Late Prehistoric. It is unclear, however, what forces may have been behind this change in subsistence focus.

There appears to be an extensive Late Prehistoric occupation in the area. Subsistence regimes still revolved around a mixed marine and terrestrial hunting and gathering strategy. The main difference is the intensive exploitation of *Donax*, demonstrating a shift from bay and estuary habitat utilization to one focused on sandy-shore species. Most of the sites appear to be short-term residential bases located either on the ridgetops or the alluvial plain. One site (SDI-10726 Locus A), however, may represent a specialized *Donax* processing center. In addition, the buried component at SDI-812/H may represent a semi-sedentary base camp based on the density and diversity of recovered cultural material; however, more extensive excavations of this component are needed in order characterize the areal extent and spatial variability of the deposit.

11.4 CONCLUSIONS

Ethnohistorically, the Luiseño were divided into several autonomous lineages or kin groups living in territorial areas with exclusive hunting and gathering rights (Bean and Shipek 1978). They probably had established either sedentary or semi-sedentary bases within the coastal area, depending on whether they used a bi-modal settlement system between the coast and inland regions or whether some groups stayed along the coast throughout the year. The obvious research question is when did this territoriality and possible sedentism become established and what factors contributed to its development? As the previous discussion clearly demonstrates, we are still a long way from understanding how the settlement and subsistence system within the Las Flores Creek locality has changed over time. Most of our information comes from what appears to be an extensive Late Prehistoric occupation of the area. Despite the number of sites investigated from this time period, none of them appear to represent a long-term residential base except perhaps the buried component of SDI-812/H. The rest of the sites are more consistent with the small, briefly occupied campsites of a classic foraging strategy.

Archaic sites are fewer in number and only offer the smallest glimpse at the overall settlement system during this period. The Red Beach site, which represents over 3,000 years of prehistory, provides the only recorded information about the end of the Archaic and the transition into the Late Prehistoric for the Las Flores Creek coastal area. The cultural deposits appear to represent repeated short-term occupations during various seasons of the year, which would be consistent with a foraging strategy. Site investigations clearly demonstrate the existence of intact deposits within the alluvial floodplain, including the only known deposit dating to the middle of the Archaic Period. The site, therefore, fills in a missing time gap and allows us to begin to piece together changes in the local settlement and subsistence system through time.

Various factors are affecting our ability to reconstruct the local settlement system through time. The current project at SDI-811 and recent excavations at SDI-812/H (Cagle et al. 1996b) have demonstrated that sites of various ages are buried beneath more recent alluviation within the extensive floodplain. More sub-surface testing is needed within the floodplain in order to document the full archaeological record in the Las Flores Creek locality. In addition, investigations at the SDI-811 have demonstrated that individual sites may have high degrees of temporal variability reflecting extensive re-occupation. In the future, more radiocarbon dates should be obtained from individual sites because one or two dates may not be sufficient to characterize the temporal range of the deposits. Finally, there is a need for more comparability in reporting methods. For example, we need to be able to construct basic density and diversity measures to allow more rigorous inter-site comparisons so that we can move beyond the more common qualitative discussions.

Another hindrance to current inter-site investigations is the need for a more refined method of defining season of occupation and duration of occupation. This investigation introduced a new method for determining the seasonality of Camp Pendleton archaeological sites: isotope analysis of *Donax*. Determining the season of occupation at a site is one of the most difficult tasks to perform, especially for a coastal site because most types of coastal flora and fauna are available year-round and offer no indication of season of exploitation. Understanding seasonality, however, is critical for reconstructing settlement patterns.

Shellfish isotope analysis offers a potential solution to this problem. It also has the greatest potential for establishing inter-site variability in seasons of occupation and duration of occupation because *Donax* is present in most of the site components within the Las Flores locality.

Perhaps the greatest hindrance to understanding the local archaeological record is the dearth of radiocarbon dates and the lack of a well-defined local chronology. At this point, investigators in the Camp Pendleton area still rely upon a wide variety of cultural chronologies using overlapping terminologies associated with different absolute dates (Reddy and Byrd 1997). Given that chronological control is essential to document and explain variability in the archaeological record, then results from SDI-811 are instructive: future research projects should emphasize collecting large suites of radiocarbon dates from individual sites.

12 MANAGEMENT RECOMMENDATIONS

Karen A. Rasmussen

12.1 SITE OVERVIEW

Site Summary

The Red Beach site (SDI-811) is an extensive Archaic/Late Prehistoric settlement situated at the mouth of Las Flores Creek. The main deposit lies within the upper portion of an alluvial fan. Cultural material lies on the ground surface throughout much of the site area; however, density of surface material is greatest in the southeast portion of the site. Excavations during the current recovery program as well as past projects (Byrd et al. 1996; Cagle et. al 1996a) reveal a rough correlation between the presence, and density, of subsurface and surface material.

The cultural material from the main deposit is composed primarily of flaked stone, animal bone, shellfish, and fire-affected rock. In addition, small amounts of Tizon Brownware ceramics, groundstone, corroded metal, glass, and botanical remains were recovered from some of the units. The bulk of the archaeological material was recovered within intact deposits located 40 to 150 cm below the surface.

A deeply buried cultural deposit of shellfish, animal bone, and a few rock fragments was located over two meters below the surface within the Ab horizon soil. The deposit was below the area being affected by the pipeline project and only a limited number of archaeological samples could be collected.

Overall, the Red Beach site appears to have been reoccupied over a long period of time, and different areas of the site were used during different time periods. Some locations saw multiple occupational episodes over time. Most of the radiocarbon dates fall into the transition between the Archaic and Late Prehistoric Period or the early part of the Late Prehistoric, while the cultural deposit within the Ab horizon corresponds to around the middle of the Archaic Period. Despite the uniformity of soil stratigraphy across the entire site, the new radiocarbon dates suggest that the depositional history of both cultural and geomorphological deposits was much more complicated than originally anticipated.

Site Integrity

The tested areas of the site appear to retain good integrity (particularly below 40 cm in depth) despite the effects of a variety of natural and cultural disturbances. In general, cultural materials in surface contexts have received the most disturbance while buried deposits have received little or no disturbance. Site disturbances from natural processes are primarily bioturbation and erosion. Several dirt roads created by tank travel have removed or disturbed cultural deposits and historic farming activities such as disking and plowing have created a plowzone and slightly compacted surficial cultural deposits. Despite such disturbances, the site retains sufficient vertical and horizontal structure to address a wide range of research questions.

Site Status

The excavated portion of SDI-811 contain a variety of intact cultural deposits that exhibit spatial and temporal variability. As such, the site can contribute important information about the prehistory of southwestern California, particularly the poorly documented coastal areas of Camp Pendleton (Bowser and Woodman 1996; Byrd et al. 1996; Cagle et al. 1995). Due to the integrity of subsurface deposits and the site's data potential to make valuable contributions to the study of prehistory, the site has been determined eligible for the National Register of Historic Places listing under criterion "d" of 36 CFR Sec. 60.4 (Byrd et al. 1996; Cagle et al. 1995).

12.2 RECOMMENDATIONS FOR CURRENT PROJECT

This section updates the mitigation recommendations provided in the Data Recovery Program for SDI-811 (Bowser and Woodman 1996).

Preconstruction Archaeological Trenching

Prior to construction, qualified archaeologists should mechanically excavate the entire pipeline trench through the high density midden. This portion of the site is defined as all areas southeast of Station Number 11+00, which is located approximately 11.5 m southeast of Trench 102 (see Figure 4-1). These excavations will involve large-scale backhoe trenching and large-mesh (1/2") dry screening to (1) increase the sample size of rare classes of data that have high data potential and (2) recover evidence of intact features and discrete activity areas that would be destroyed during construction. At this site, rare data classes include, but are not limited to, groundstone, flaked stone tools, ceramics, and features. A stratigraphic profile of the trench should be drawn by a qualified geoarchaeologist or geomorphologist to document the natural and cultural stratigraphy of the site.

Within each identifiable stratum, trenching should proceed in 20 cm levels except for the 40 cm plowzone, which can be excavated in one level. Excavated matrix should be screened through 1/2" mesh, which will recover the targeted types of remains (e.g., groundstone, projectile points). In general, common artifacts recovered in sufficient quantities from previous testing (e.g., debitage, faunal remains) do not need to be collected unless from

features or other contexts not previously investigated. Once discovered, features or other discrete concentrations of cultural materials, such as cultural deposits from Ab horizon contexts, should be excavated by hand, processed accordingly, and analyzed according to the Data Recovery Plan (Bowser and Woodman 1996).

If the soils do not pass well through the dry screen, the field director may reduce, modify, or eliminate screening procedures. All soils that cannot be effectively screened should be spread next to the trench and carefully inspected for artifacts of interest. In the absence of dry screening, the primary value of preconstruction trenching would be the location of features and the collection of relatively large, highly visible tools. Bifaces and other chert tools would still be recovered, but there would be some reduction in absolute quantities.

Special attention should be given to the region around and within the known fire-affected rock deposits. At this point, the exact boundaries of the two areas are unclear. The preconstruction trenching will be instrumental in providing a better understanding of the areal extent of the two cultural deposits. In addition, special attention should be made to investigate any exposed Ab deposits for signs of cultural material. The samples recovered from the lower deposit of the site, to date, are too small to provide much information, and any new data would be extremely useful and significant to our understanding of deeply buried archaeological material.

Radiocarbon Dating

The radiocarbon samples from the Red Beach site yielded a wide range of dates from B.C. 1395 to A.D. 1000 for the cultural material within the upper portion of the site. We recommend that more samples be submitted for radiocarbon dating from some of the existing cultural material as well as potential future discoveries. Priority should be placed on dating the materials located beneath the fire-affected rock scatters to determine how the archaeological material below 80 cm in depth relates in time to the fire-affected rock deposits. More samples should be run from Unit 109 to investigate how the upper deposits of the unit, represented by AU 2, relate in time to the lower deposits, represented by AU 3. In addition, it would be useful to obtain a date from one of the units in the northwestern section of the site, especially Unit 110. So far, all of the radiocarbon samples have been confined to the higher density deposits in the southeastern portion of the site.

Finally, samples of shell or charcoal for radiocarbon dating should be recovered from any new features or discrete deposits discovered during the preconstruction trenching and/or monitoring.

Monitoring and Emergency Discoveries

All construction-related activities that may disturb surface and subsurface archaeological deposits at SDI-811 (e.g., clearing of vegetation, grading, pipeline trenching, and excavation of vault pits) should be monitored by a qualified archaeologist. Formal artifacts and temporally diagnostic artifacts should be collected, recorded contextually, and mapped. All features should be excavated and recorded as described above. Special attention should be given to the excavation of the vault pits because these will invariably dig through one or more potentially cultural-bearing Ab horizon soils.

Discovery of Burials and Burial-Associated Artifacts

Burials and burial-associated artifacts discovered during the course of the project will be treated according to the Discovery Treatment Plan included within the project's Finding of Effect. These procedures are consistent with those established by the Native American Graves Protection and Repatriation Regulations (43 CFR 10).

12.3 PROTECTION RECOMMENDATIONS

SDI-811 retains sufficient site integrity to warrant future protection measures. Procedures should be followed to minimize impacts to both the surface and subsurface cultural deposits. Any future projects that will affect ground integrity should be monitored and potentially mitigated by qualified archaeologists.

The Red Beach site lies within an important training area for the Marine base. Due to pre-existing surface disturbance to the site (see *Site Integrity*), the use of the area by foot soldiers and rubber-tired transportation vehicles would have limited effects on site integrity and could be allowed as long as the site is monitored periodically (see below). However, no track vehicles, mechanical disturbance, or other earth moving activities should be allowed within the boundaries of the site.

Following the recommendations of ASM Affiliates (Byrd et al. 1996), the site should be monitored semi-annually in order to investigate and document continuing natural and human disturbances to the site. Lateral erosion of the Las Flores Creek, in particular, poses a threat to site integrity. The site should be checked after any flooding or creek erosional event to document impacts on archaeological deposits within the area. Adverse erosional impacts to significant archaeological deposits should be avoided, if feasible, by engineering solutions developed to slow the lateral erosion of the creek.

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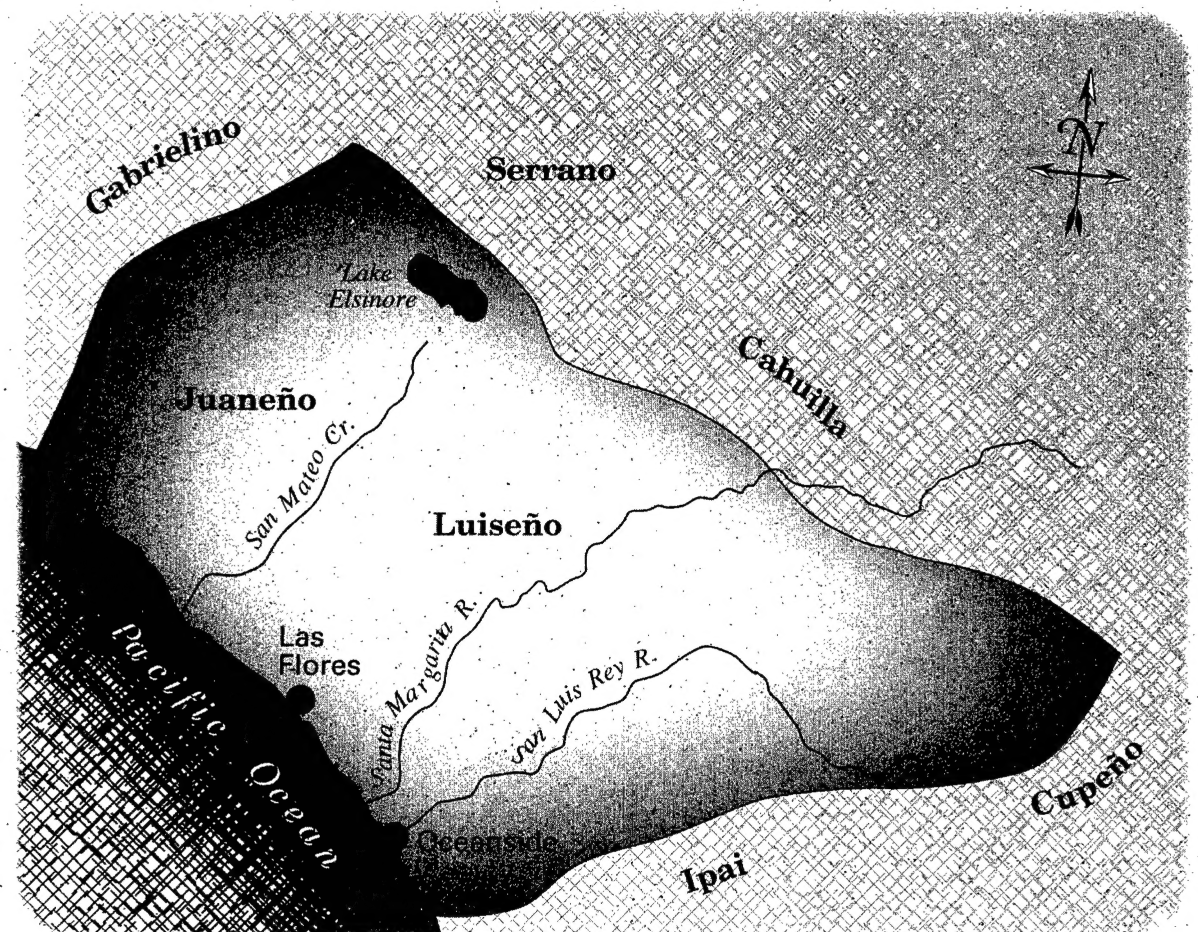

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